dust that a worker may breathe over a period of years. It is further apparent that to obtain such a picture, daily dust counts at each specific job in each ship compartment and in the shop together with the time spent on each job would have to be compiled separately for each worker. In this respect, asbestos pipe covering differs markedly from the asbestos textile industry where dust concentrations for an operation do not fluctuate widely and where a worker will usually remain at a specific job for some years.

A further factor in maintaining a low incidence of asbestosis is that in band saw cutting, grinding, and cement mixing only one or two men are involved and the work is usually done at infrequent intervals such as several times a week.

Finally, pipe coverers also apply glass wool, rock wool, magnesia, and other types of non-asbestos insulation, all of which decreases the amount of exposure to asbestos dust. It seems likely to us that if the pipe coverers studied had worked steadily at any of the above operations where the amount of asbestos dust in the air was consistently high, the incidence of asbestosis among these workers would have been considerably greater. In view of the varied character of the environmental dust exposure in the pipe covering industry on naval vessels, it is manifestly impossible to set a threshold.

VI. Conclusions

1. The character of asbestos pipe covering industry on board naval vessels is such that conclusions drawn from other asbestos industries such as textiles, cannot be applied.

2. The operations of band saw cutting, grinding, cement mixing, and installation on board ship should be equipped with exhaust ventilation to keep the total dust concentration low.

3. The incidence of asbestosis among pipe coverers in the shipyards studied was low, 0.29 per cent or 3 cases out of 1074. In view of the nature of shipyard pipe covering work, this low incidence is not surprising.

4. Since each of the 3 cases of asbestosis had worked at asbestos pipe covering in shipyards for more than 20 years, it may be concluded that such pipe covering is not a dangerous occupation.

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CHAPTER 39 THERMAL INSULATION

CONTENTS

SECTION I. MACHINERY AND PIPING INSULATION

Part 1. General

39-1. DEFINITIONS

1. Insulating material is defined as the material employed to offer resistance to the flow of heat.

2. Lagging is defined as the protective and confining covering or jacket placed over the actual insulating materials.

3. Fastening is defined as the miscellaneous items with which insulating material is attached to the surface being covered and with which lagging is fixed to the insulating material.

4. Insulation is defined as the composite covering including insulating material, lagging, and fastening.

39-2. REASONS FOR INSULATING

1. In every power plant there is a heat loss from all heated surfaces and a heat flow to all cooled surfaces. Heat flow may occur in three ways; by conduction, by convection, and by radiation.

2. Conduction is the heat flow from one part of a body to another part of the same body, or from one body to another with which it is in physical contact, without displacement of the particles of the body. This manner of heat flow is most important in insulation as it is the low conduction which results in the greatest temperature differential between a hot insulated surface and the atmosphere (as in steam piping insulation), or the relatively warm atmosphere and a cold surface (as in refrigerating plant insulation). Heat transfer from insulated pipes or large blanketed or cemented surfaces (turbines, evaporators, etc.) to the outer surface of their lagging is included in this mode. Conduction is associated with solids and comparison of materials in this respect is measured by a factor called the "thermal conductivity" which expresses rate of conductivity in British thermal units (B. t. u.) per inch of thickness per hour per square foot of area per degree Fahrenheit temperature differential.

3. Convection is the transfer of heat from one point to another within a fluid, gas, or liquid, by circulating or mixing of one portion of the fluid with another. These currents are produced by warm fluid being displaced by heavier cold fluid. It is of interest to note that convection reduces the effectiveness of air space insulation unless such space is very small.

4. Radiation is the method of heat transfer by which a hot body gives off energy in the form of radiant heat which is emitted in all directions. Radiant heat, like light, travels in straight lines and with the speed of light. The surface condition greatly affects the ability of a body to radiate heat. Dull, dark, rough finished surfaces are the best radiators. Conversely, bright, shiny, smooth surfaces are good heat reflectors.

5. In order to minimize the transfer of heat from or to a body or surface which is hotter or colder, respectively, than the surrounding atmosphere, thermal insulation is applied. This thermal insulation is a material or materials of low thermal conductivity. (See par. 39-2). While increasing the economy of the plant, thermal insulation also reduces the quantity of air necessary for ventilating and cooling requirements and prevents injury of personnel due to burns from contact with hot parts of apparatus. It also insures more uniform heat distribution within equipment. Another function of thermal insulation is to prevent "sweating" of cold surfaces on which atmospheric moisture condenses thus causing undesirable dripping as well as accelerated corrosion of the metal. Insulation must be sufficiently effective to reduce heat losses and lower surface temperatures to a degree which will permit habitable conditions in a specific space or compartment.

Part 2. Materials

39-11. INSULATING MATERIALS

1. The following requirements should be met as nearly as possible by thermal insulating materials:
   a. Low heat conductivity.
   b. Noncombustibility.
   c. Lightweight.
   d. Capability of easy molding and application.
   e. Moisture repellent.
   f. Noncorrosive, insoluble, and chemically inactive.
   g. Composition, structure, and characteristics unchanged by temperatures at which it is to be used.
   h. Once installed, should not cluster, become lumpy, disintegrate or build up in masses from vibration.
   i. Vermin proof.

2. Insulating materials are available in the following forms in accordance with Navy Department Specifications:
   a. Molded sectional pipe covering:
      Thermal insulation pipe covering, MIL-P-2781
      Thermal cellular glass block and pipe covering HH-I-551
      Molded cork (with fire resisting compound) pipe covering, MIL-P-876
   b. Block:
      Thermal insulation block, MIL-I-2819

c. Batts, blankets and felts:
Roll asbestos felt, MIL-F-20077
Asbestos insulating felt, MIL-F-15091
Fibrous glass batt insulation, MIL-I-15475
Mineral wool blanket insulation, MIL-I-2818
Thermal glass fiber insulation felt, MIL-I-16411
Thermal fibrous glass insulation felt, (flexible) MIL-I-16022
Thermal insulating tape, MIL-T-15349

d. Plastic:
High temperature insulation cement, MIL-C-2861
Finishing cement, MIL-C-2908

3. Thermal insulation pipe covering, Military Specification MIL-P-2781, grade I, usually is 85 percent magnesia and it is suitable for temperatures 125° F up to 500° F. Eighty-five percent magnesia is a molded product formed from a combination of 85 percent magnesium carbonate with about 15 percent asbestos fiber for strength and bond. It is made in standard and light density (class b) which weighs 13 pounds per cubic foot. The pipe covering is furnished in cylindrical sections 3 feet long, split in half lengthwise. Larger sizes are furnished in quadrant or segmental form. Sections which become broken may be reused as plastic cement by breaking up the material and mixing it with water.

4. Thermal insulation pipe covering, Military Specification MIL-P-2781, grade II, class c, is a fibrous product usually formed from a uniform mixture of amosite asbestos fibers (composed mostly of pure silica and the oxides of iron and magnesium) and held together with a sodium silicate (water glass) binder. Its maximum density is 15 pounds per cubic foot. It is considerably harder than either of the magnesia materials in paragraph 39–11 and comparable to the standard magnesia covering as a good insulator. It is resilient, tough, and withstands vibration. It has a smooth, gray, finished surface. Molded fibrous asbestos saws and cuts neatly with ordinary tools. It can be used for temperatures up to 750° F. and is manufactured in cylindrical sections 3 feet long, split in half lengthwise.

5. Class d under grade II of Military Specification MIL-P-2781, covers compounded materials. These are products which have been developed comparatively recently and which vary in composition. Grade II materials are suitable for temperatures up to 750°.

6. Thermal insulation pipe covering, Military Specification MIL-P-2781, grade III, class e, light and heavy density is a compounded material usually consisting of molded calcium silicate or diatomaceous earth. It is used in a single layer or of combination pipe covering, the inner layer of which contacts the hot surface and the outer layer which is 85 percent magnesia or grade II of the type described in paragraph 39–11. This class of material is suitable for temperatures from 751° up to 1050° F.

7. Thermal insulation pipe covering, Military Specification, MIL-P-2781, grade III, class f, is a fibrous material usually consisting of asbestos similar to that described in paragraph 39–11, but it is much harder and withstands high temperatures. It is used in a single layer or in the form of combination pipe covering, the inner layer of which contacts the hot surface and is high temperature material. The outer layer is class c material. This pipe covering is available as combined sections with the two classes formed together to give the appearance and workability of a uniformly molded material. The max. density is 25 pounds per cubic foot. This material is suitable for temperatures from 751° to 1050° F.

8. The description herein of materials covered by Military Specification MIL-P-2781 is based on materials as procured and their naval applications. All the common pipe covering materials have been discussed. As newly developed products are found to be suitable for naval use, such pipe coverings probably will be installed in addition to the common materials.

9. Molded cork pipe covering, Military Specification MIL-P-876, is composed of cork joined by and coated over with a vapor-sealing compound. The pipe covering sections are made of pure granulated cork compressed into molds and held together by the natural cork gum as a binder. The fire retardant vapor-sealing compound is composed of chlorinated resins, drying oils, dryers, and fillers. A volatile solvent is added to attain the necessary fluidity for easy application with a stiff brush or trowel. At the time of installation the untreated molded cork insulating material is coated on all surfaces with the vapor seal. Each delivery of cork includes sufficient copper-clad steel wire and vapor seal for complete application. The molded cork is available in the following types: Ice water thickness, brine thickness, and special brine thickness. Pipe covering is furnished in cylindrical sections 3 feet long, split in half lengthwise. This material is of low thermal conductivity, high structual strength, almost free from shrinkage, resists moisture penetration when thoroughly coated, and acts as a good insulating material for refrigeration service.

10. Molded cellular glass thermal insulation Federal Specification HH-I-551 is furnished in 3 types:

Type I – blocks
Type II – pipe and tubing insulation
Type III – special shapes

The material consists of glass composition which has been foamed or cellulated containing separate hermetically sealed glass cells each a tiny dead air insulating space. Non-combustible rot-proof and acid proof. Furnished in 7 classes for a temperature range from minus 50 up to plus 400° F. The weight is between 8 to 10 lbs per cu. ft. available in lengths of 18" split in half lengthwise. Not recommended for vibrating machinery.

11. Thermal insulation block, Military Specification, MIL-I-2819, is furnished in 3 classes according to the allowable temperatures for which the materials are suitable. Class a of the specification covers insulating material for temperatures up to 500° F. The maximum density for this class is 15 pounds per cubic foot. Block insulation is flat and rectangular. Asbestos block should be used where unusually high resistance to compression is required.

12. Class b of Military Specification, MIL-I-2819, temperature range of 501° to 1,000° F. is of high temperature molded asbestos. Diatomaceous earth high temperature insulating material in molded block form also is available for this service. It is described in paragraph 39–11.

13. For the higher range of temperatures, 1,001° to 1,500° F. covered by class c of Military Specification, MIL-I-2819, diatomaceous earth material in block form is used.

14. Roll asbestos felt, Military Specification, MIL-I-15091, is composed of medium long asbestos fiber and organic sizing. The materials are felted into sheets, with

an indented surface of such flexibility that it may be folded, bent, or wrapped around piping and equipment. It is furnished in rolls 1/8 or 1/4 inch thick and 3 feet wide. The 1/4-inch roll weighs about 1.2 pounds per square foot. This material is suitable for temperatures up to 900° F.

15. Asbestos insulating felt, Military Specification MIL-I-15091, is furnished in type A, plain, and type B, water repellent for cold piping. Plain felt is composed of asbestos fibers and cotton and binding materials if required. Water-repellent felt is composed of asbestos fibers, cotton treated with a suitable repellent agent, and a cotton fabric encasement. Asbestos felt has a maximum density of 12 pounds per cubic foot. Plain asbestos felt is furnished in rolls 50 feet long by 60 inches wide and in thicknesses of 3/4, 1, and 1½ inches. It has perhaps the widest range of uses of the insulating materials as it has flexibility for fitting around valves or other irregular surfaces and it is suitable for a temperature range from cold water to 900° F. Water-repellent asbestos felt is furnished in rolls 50 feet long and in widths from 3 to 60 inches; thicknesses are 3/4 or 1 inch. Thermal fibrous glass insulation felt, Military Specification MIL-I-16022 is processed from a molten state into fibrous form and is free from nonfibrous material (shot) bonded with a binder to form flexible felt. This felt is used as light weight flexible fibrous glass felt for thermal insulation of densities from 0.5 lbs. per cu. ft. up to 3 lbs. per cu. ft. in classes from 1 to 6. It is incombustible and fire retardant. Thermal glass fiber insulation felt Military Specification MIL-I-16411 is composed of staple glass fibers felted into rowings and woven or bound with wire inserted asbestos thread to form a flexible blanket. It is used as insulation felt for thermal control of machinery and equipment at temperature up to 1200° F. The felt is furnished in widths of 60 inches and in rolls 50 feet in length. The thicknesses are 3/4", 1" and 1½".

16. Fibrous glass felt insulation, Military Specification MIL-I-15475, is composed of glass fibers bonded together to form a semirigid batt. The fibrous glass is pure glass in fibrous form and is inorganic and fireproof and resistant to salt water and some chemical actions. It cannot mildew, decay, or provide sustenance to insects, rodents, or vermin. The batts are furnished in two grades, one weighing 6 pounds per cubic foot and the other 4.5 pounds. Standard dimensions are 48 inches long by 24 inches wide by 1 to 4 inches thick. When this material is used at elevated temperatures, the binding agent burns out at a point between 450° and 600° F. Hence, batts should be enclosed by sheet steel for support when subjected to temperatures between 450° and 900° F. The material is suitable for insulating boiler uptakes.

17. Mineral wool blanket insulation, Military Specification MIL-I-2818, consists of fibers from slag, glass, or argillaceous limestone made by a process of melting, blowing, or drawing, and annealing. The blankets are felted and reinforced by wire netting or metallic lathing on both sides. The material is suitable for use at temperatures up to 900° F.

18. Thermal insulating tape, Military Specification MIL-I-15349, is composed of a woven asbestos jacket enclosing either an asbestos fiber or fibrous glass felting or sliver. The jacket is woven from yarn containing not less than 90 percent by weight on the hot side and not less than 80 percent by weight on the cold side of asbestos

fiber; it may be either in one tubular piece or fabricated of asbestos cloth sewed into tubular form. The tape is supplied in two forms, one for spiral wrapping and the other for lateral wrapping. That for spiral wrapping is 2 to 2-3/8 inches wide and 1/4 to 3/8 inch thick. The tape for lateral wrapping is 5¼ inches wide and 3/8 inch thick. It is suitable for temperatures up to 750°.

19. High temperature insulation cement, Military Specification MIL-C-2861, is available in two types. Type A is the diatomaceous earth or exfoliated mica type and is composed of a dry mixture of suitable grades of such refractory material ground fine, asbestos fibers, and clay binders, thoroughly mixed to obtain uniform distribution of the ingredients. Type B is the rock or mineral-wool type which consists of a dry mixture of rock or mineral-wool fibers, asbestos fibers, and binders, thoroughly mixed to obtain uniform distribution of the ingredients. This latter type is most suitable for monolithic insulation. The composition of the cement is such that when properly wetted with fresh water, it can be applied with a trowel or by hand to hot and cold surfaces. One hundred pounds of dry cement will cover 50 square feet of surface to a thickness of 1 inch. After application it weighs a maximum of 30 pounds per cubic foot. The cement is reclaimable for reuse. The thermal conductivity of this material is higher than the nonplastic materials. All cements covered by Military Specification MIL-C-2861 are suitable for use at temperatures from 100° to 1,000° F., and some may be used for 1,800° F. service. It is very important that all rock or mineral-wool type cements which may be used shall have corrosion-resisting properties conforming to the specification. Type B cement can be used to fill all cracks when using block or sectional pipe insulation used on fittings or valves, over wire netting to smooth the surface.

39-12. LAGGING MATERIALS

1. The definition of lagging in paragraph 39-1 describes the purpose of this item. It protects the relatively soft insulating material from mechanical abuse to which it is exposed aboard ship as a result of men climbing over piping and the necessary handling of equipment. It supports the insulating material which is subjected to continual vibration. The lagging provides a smooth finish to be painted.

2. Materials in accordance with the following Federal and Military Specifications are used as lagging:

a. Cloth:
Asbestos cloth, thread and tape, SS-C-466
Fibrous glass cloth, tape and thread (for lagging insulation), MIL-C-20079

b. Brattice cloth Military Specification MIL-C-788 is a fire resistant cotton cloth used for repairing surface of fibrous glass insulation board and as lagging material for thermal insulation, asbestos felt, fibrous glass felt, cork, high temperature insulating cement and mineral wool for pipe temperatures from minus 20 up to including 500° F.

c. Paper:
Flameproof and water - repellent sheathing paper, MIL-P-15005

d. Board:
Asbestos millboard, HH-M-351

e. Plastic:
Asbestos insulation finishing cement, MIL-C-2908

f. Metallic:
Zinc coated (galvanized), sheet steel, QQ-S-775

3. Asbestos cloth, thread, and tape, Military Specification, SS-C-466, are made of good quality chrysotile asbestos and organic fibers for use as a lagging material or jacket over thermal insulation and as a wrapping on engine exhaust pipes. The grades of cloth and tape are classified by the maximum allowable cotton content. Type I cloth and type IV tape are intended for use as the lagging material for insulation on pipe or tubing at all temperatures; it is not to be used on valves, fittings, and flanges if it will be in contact with heated metal. It may be used on valves, fittings, and flanges where the temperature of the insulated surface is 500° F. or less, and for temperatures over 500° F. on applications such as butt-welding end fittings where it is desirable to lag the fittings with the material used on the tubing. Grade A, 80 percent asbestos cloth in three classes is furnished with a blue stripe woven into the finished edge of this material which may be asbestos or combination of asbestos and glass yarn. Grade B, 90 percent asbestos cloth, is furnished with a red stripe woven in and is intended for use as the outside lagging on removable and replaceable covers for flanges and fittings or other applications on valves, fittings, and flanges where the temperature of the insulated surface is more than 500° F. Ninety-five per cent asbestos cloth Grade C and D is furnished with or without wire insertion. That with the wire, Grade C, is intended for use as the inside lagging on removable and replaceable covers for valves, flanges, and fittings at all temperatures. The wire adds to the strength and stiffness of the lagging. Grade D, 95 percent asbestos cloth without the wire, is intended for the same conditions as Grade C when strength and stiffness is not necessary. This material is furnished with a green stripe woven into the finished edge. Type III asbestos sewing thread and a Type II yarn reinforced with wire are available under the specification. Brattice cloth Military Specification MIL-C-788.

4. Fibrous glass cloth, tape, and thread Military Specification, MIL-C-20079, are manufactured from a good quality of fibrous-glass yarn. The tapes and cloths are made in various weights and weaves, the most frequently used being described herein. Tight, satin-weave, lightweight cloth is recommended for straight pipe. For irregular surfaces, tight, broken-twill weave, heavyweight cloth should be used. Medium, plain weave, lightweight tape in 2, 3 and 4 inch widths is suitable for curved pipe in particular. Tapes are applied with a minimum amount of labor and time. The sewing thread shall be of continuous filament yarn. *Fibrous glass materials are not recommended for use where lagging is exposed to mechanical injury.* The material may be used for lagging surfaces with internal temperatures up to 1050° F., but should not be used on removable and replaceable covers nor where it will be in contact with hot metal surfaces.

5. Sheathing paper, Military Specification MIL-P-15006 is made in one type. The flameproof and water-repellent paper does not support combustion and absorbs only the specified small weight of water. This material is used in conjunction with other lagging; see the instructions for insulation of anti-sweat piping in part. The paper is supplied in rolls 36 inches wide.

6. Asbestos millboard, Federal Specification HH-M-351, is composed of asbestos fiber and binding material formed under pressure into a sheet. It has a fair amount of insulating value for temperatures up to 400° F. but is mostly used as outside lagging on removable insulating covers to which it gives stiffness. It is available in thicknesses of from 1/8 to 1/2 inch in sheets the standard size of which is 42 by 48 inches. The maximum acceptable weight is 6.5 pounds per square foot of material 1 inch thick.

7. Asbestos finishing cement, Military Specification MIL-C-2908 available in two types. Type I is composed of asbestos fibers, fillers, and suitable binders thoroughly mixed to obtain a uniform distribution of the ingredients. The composition is such that when properly wetted with fresh water, it can be readily troweled to a smooth surface. Type II the hydraulic setting cement is composed of a dry mixture of nodulated rock or mineral wool fibers and a hydraulic binder. One hundred pounds of cement has a covering capacity, applied and dried, of 30 broad feet. Asbestos cement Type I is used as a surface finish over insulating material to provide a hard, smooth finish to which lagging is applied. Type II may be used insulating cement, for small valves and fittings up to in size.

8. Galvanized sheet steel, Specification 47S29, is used as described in the sections on application of insulation.

39–13. ADHESIVE MATERIALS

1. Adhesives which comprise one type of fastening as defined in paragraph 39–1 are covered by the following Federal and Military Specifications.

Fibrous adhesive insulation cement, MIL-A-15199
Adhesive and sealing cements, MIL-C-3316
Sodium silicate solution (33.5° Baumé), O-S-605

2. Fibrous adhesive, Military Specification MIL-A-15199, is suitable for securing woven asbestos cloth to insulating material employed on piping or other applications. The cement is ready for use without heating or addition of other ingredients, except that it may be furnished in the unmixed form to be mixed just prior to use. It will not deteriorate for one year when enclosed in airtight metal containers. When used for fixing lagging or insulating materials to other than metal surfaces, 75 pounds of adhesive will cover about 100 square feet. Adhesive cement per Military Specification MIL-A-15199 must never be used for securing fibrous glass cloth or insulation since it causes disintegration of such materials. Therefore, this cement is not to be used with type I class 5 cloth Federal Specification SS-C-466.

3. Adhesive insulation cement Military Specification MIL-C-3316 is suitable for securing all lagging materials. It has the best properties of the adhesives described herein. Cements in accordance with the specification will not injuriously affect insulation or glass cloth. This cement is furnished in three types.

4. Sodium silicate solution, Federal Specification O-S-605, may be used for fastening asbestos cloth. The cloth, when soaked in the silicate of soda and applied to

the surface, molds into position and dries to form a hard, firm finish which resists abrasion. The remarks in paragraph 39–13 2. in regard to the use of fibrous adhesive cement with fibrous glass materials apply also to sodium silicate solution.

Part 3. Application of Thermal Insulation General

39–21.

1. Cloth and tape lagging should be covered with one coat of fire-retardant paint, per Military Specification JAN–P–702, after installation. The inside covers of removable blanket insulation need not be painted.

2. All steampiping, valves, and fittings up to 400° F. located in positions exposed to the weather or to salt water spray may be insulated with cellular glass covering specification HH–I–551, lined inside and at points with bedding compound lagged as described in Buship Instruction 9390.3A, Ser. 548–2492 dtd 13 September 1955. However vibrating machinery or piping systems such as steam to the whistle shall not be insulated with cellular glass. Where it is not feasible to apply insulation, paint the piping with heat-and weather-resistant paint, and install suitable guards to protect personnel. Also use metal lagging where necessary to shield the insulation from damage. Metallic lagging,

galvanized sheet steel, may be painted for appearance with one coat of zinc chromate primer, formula 84, followed by one coat of fire-retardant paint per Military Specification JAN–P–702.

3. Where the detailed instructions which follow hereafter do not specifically cover any surface requiring insulation, such surface should be insulated in a manner similar to the requirements covering a condition which most nearly approximates that of the surface in question.

4. At least once a year and preferably at 6-month intervals, a careful inspection should be made of insulation. All broken or loose insulating or lagging materials should be securely fastened in accordance with instructions herein. If much material is broken, a complete reinstallation is recommended.

5. In the course of emergency repairs as a result of damage, insulation is to be stripped from piping in flooded compartments if practicable. This procedure will prevent serious corrosion of piping by insulation which carries a large amount of water even subsequent to unwatering operations.

6. The following tables indicate various approved insulating, lagging, and fastening materials to be used and minimum thicknesses required for all services and temperature ranges.

TABLE 1.--Compounded insulating material, Mil. Spec. MIL-I-2781, thickness for hot piping

Pipe size (inches i.p.s.)	Temperature range (degrees F.)	Class		Nominal thickness (inches)		
		Inner layer	Outer layer	Inner layer	Outer layer	Total
1/2, 3/4, and 1	125-388	b	—	1	—	1
	389-500	b	—	1-1/2	—	1½
	501-750	d or e	—	2	—	2
	751-950	e	—	2	—	2
	951-1050	e	b	2	1-1/2	3-1/2
1-1/4 and 1-1/2	125-388	b	—	1	—	1
	389-500	b	—	2	—	2
	501-750	d or e	—	2	—	2
	751-950	e	—	2	—	2
	951-1050	e	b	2	1-1/2	3-1/2
2	125-338	b	—	1-1/2	—	1-1/2
	339-388	b	—	2	—	2
	389-500	b	—	3	—	3
	501-750	d or e	—	3	—	3
	751-900	e	b	1-1/2	1-1/2	3
	901-1050	e	b	1-1/2	1-1/2	3
			b	2	1-1/2	3-1/2
2-1/2	125-338	b	—	1-1/2	—	1-1/2
	339-388	b	—	2	—	2
	389-500	b	—	3	—	3
	501-750	d or e	—	3	—	3
	751-900	e	b	1-1/2	1-1/2	3
	901-950	e	b	1-1/2	1-1/2	3
	951-1050	e	b	2	1-1/2	3-1/2
			b	2	1-1/2	3-1/2
3 and 4	125-338	b	—	1-1/2	—	1-1/2
	339-388	b	—	2	—	2
	389-500	b	—	3	—	3
	501-750	d or e	—	3	—	3
	751-900	e	b	1-1/2	2	3-1/2
	901-950	e	b	1-1/2	2	3-1/2
	951-1050	e	b	2	1-1/2	3-1/2
			b	2-1/2	1-1/2	4
3-1/2 and 4-1/2	125-338	b	—	1-1/2	—	1-1/2
	339-388	b	—	2	—	2
	389-500	b	—	3	—	3
	501-750	d or e	—	3	—	3
	751-900	e	b	1-1/2	2	3-1/2
	901-950	e	b	1-1/2	2	3-1/2
	951-1050	e	b	2	1-1/2	3-1/2
			b	2-1/2	1-1/2	4
5	125-338	b	—	1-1/2	—	1-1/2
	339-388	b	—	2	—	2
	389-500	b	—	3	—	3
	501-750	d or e	—	3	—	3
	751-900	e	b	1-1/2	2	3-1/2
	901-950	e	b	1-1/2	2	3-1/2
	951-1050	e	b	2	1-1/2	3-1/2
			b	3	2	5
6	125-338	b	—	1-1/2	—	1-1/2
	339-388	b	—	2	—	2
	389-500	b	—	3	—	3
	501-750	d or e	—	3	—	3
	751-900	e	b	1-1/2	2	3-1/2
	901-950	e	b	1-1/2	2	3-1/2
	951-1050	e	b	2	2	4
			b	3	2	5
7	125-338	b	—	1-1/2	—	1-1/2
	339-388	b	—	2-1/2	—	2-1/2
	389-500	b	—	3	—	3
	501-750	d or e	—	4	—	4
			b	1-1/2	2	3-1/2

TABLE 1.--Compounded insulating material, Mil. Spec. MIL-I-2781, thickness for hot piping--Con.

Pipe size (inches i.p.s.)	Temperature range (degrees F.)	Class		Nominal thickness (inches)		
		Inner layer	Outer layer	Inner layer	Outer layer	Total
7--Continued	751-900	e	b	1-1/2	2	3-1/2
	901-950	e	b	2	2	4
	951-1050	e	b	3	2	5
8, 9, and 10	125-338	b	--	1-1/2	--	1-1/2
	339-388	b	--	2-1/2	--	2-1/2
	389-500	b	--	3	--	3
	501-750	d or e	--	4	--	4
			b	2	2	4
	751-900	e	b	2	2	4
	901-950	e	b	2-1/2	2	4-1/2
	951-1050	e	b	3	2	5
11 and larger	125-338	b	--	1-1/2	--	1-1/2
	339-500	b	--	3	--	3
	501-750	d or e	--	4	--	4
			b	2	2	4
	751-900	e	b	2	2	4
	901-950	e	b	2-1/2	2	4-1/2
	951-1050	e	b	3	2	5

TABLE 2.--Fibrous insulating material, MIL-I-2781 thickness for hot piping

Pipe size (inches i.p.s.)	Temperature range °F.	Class		Nominal Thickness (inches)		
		Inner layer	Outer layer	Inner layer	Outer layer	Total
1/2, 3/4, and 1	125-388	c	- - - - - - -	1	- - - - - - -	1
	389-500	c	- - - - - - -	1-1/2	- - - - - - -	1-1/2
	501-750	c or	- - - - - - -	2	- - - - - - -	2
		f	- - - - - - -	2	- - - - - - -	2
	751-950	f	- - - - - - -	2	- - - - - - -	2
	951-1050	f	c - - - - - -	2	1-1/2	3-1/2
1-1/4 and 1-1/2	125-388	c	- - - - - - -	1	- - - - - - -	1
	389-500	c	- - - - - - -	2	- - - - - - -	2
	501-750	c or	- - - - - - -	2	- - - - - - -	2
		f	- - - - - - -	2	- - - - - - -	2
	751-950	f	- - - - - - -	2	- - - - - - -	2
	951-1050	f	c - - - - - -	2	1-1/2	3-1/2
2	125-338	c	- - - - - - -	1-1/2	- - - - - - -	1-1/2
	339-388	c	- - - - - - -	2	- - - - - - -	2
	389-500	c	- - - - - - -	3	- - - - - - -	3
	501-750	c or	- - - - - - -	3	- - - - - - -	3
		f	c - - - - - -	1-1/2	1-1/2	3
	751-900	f	c - - - - - -	1-1/2	1-1/2	3
	901-1050	f	c - - - - - -	2	1-1/2	3-1/2
2-1/2	125-338	c	- - - - - - -	1-1/2	- - - - - - -	1-1/2
	339-388	c	- - - - - - -	2	- - - - - - -	2
	389-500	c	- - - - - - -	3	- - - - - - -	3
	501-750	c or	- - - - - - -	3	- - - - - - -	3
		f	c - - - - - -	1-1/2	1-1/2	3
	751-900	f	c - - - - - -	1-1/2	1-1/2	3
	901-950	f	c - - - - - -	2	1-1/2	3-1/2
	951-1050	f	c - - - - - -	2	1-1/2	3-1/2
3 and 4	125-338	c	- - - - - - -	1-1/2	- - - - - - -	1-1/2
	339-388	c	- - - - - - -	2	- - - - - - -	2
	389-500	c	- - - - - - -	3	- - - - - - -	3
	501-750	c or	- - - - - - -	3	- - - - - - -	3
		f	c - - - - - -	1-1/2	2	3-1/2
	751-900	f	c - - - - - -	1-1/2	2	3-1/2
	901-950	f	c - - - - - -	2	1-1/2	3-1/2
	950-1050	f	c - - - - - -	2-1/2	1-1/2	4
3-1/2 and 4-1/2	125-338	c	- - - - - - -	1-1/2	- - - - - - -	1-1/2
	339-388	c	- - - - - - -	2	- - - - - - -	2
	389-500	c	- - - - - - -	3	- - - - - - -	3
	501-750	c or	- - - - - - -	3	- - - - - - -	3
		f	c - - - - - -	1-1/2	2	3-1/2
	751-900	f	c - - - - - -	1-1/2	2	3-1/2
	901-950	f	c - - - - - -	2	1-1/2	3-1/2
	951-1050	f	c - - - - - -	2-1/2	1-1/2	4

TABLE 2.--Fibrous insulating material, MIL-I-2781 thickness for hot piping--Continued

Pipe size (inches i.p.s.)	Temperature range °F	Class		Nominal Thickness (Inches)		
		Inner layer	Outer layer	Inner layer	Outer layer	Total
5	125-338	c	-	1-1/2	-	1-1/2
	339-388	c	-	2	-	2
	389-500	c	-	3	-	3
	501-750	c or-	-	3	-	3
		f	c	1-1/2	2	3-1/2
	751-900	f	c	1-1/2	2	3-1/2
	901-950	f	c	2	1-1/2	3-1/2
	951-1050	f	c	3	2	5
6	125-338	c	-	1-1/2	-	1-1/2
	339-388	c	-	2	-	2
	389-500	c	-	3	-	3
	501-750	c or-	-	3	-	3
		f	c	1-1/2	2	3-1/2
	751-900	f	c	1-1/2	2	3-1/2
	901-950	f	c	2	2	4
	951-1050	f	c	3	2	5
7	125-338	c	-	1-1/2	-	1-1/2
	339-388	c	-	2-1/2	-	2-1/2
	389-500	c	-	3	-	3
	501-750	c or-	c	4	-	4
		f	c	1-1/2	2	3-1/2
	751-900	f	c	1-1/2	2	3-1/2
	901-950	f	c	2	2	4
	951-1050	f	c	3	2	5
8, 9, and 10	125-338	c	-	1-1/2	-	1-1/2
	339-388	c	-	2-1/2	-	2-1/2
	389-500	c	-	3	-	3
	501-750	c or-	-	4	-	4
		f	c	2	2	4
	751-900	f	c	2	2	4
	901-950	f	c	2-1/2	2	4-1/2
	951-1050	f	c	3	2	5
11 and larger	125-338	c	-	1-1/2	-	1-1/2
	339-500	c	-	3	-	3
	501-750	c or-	-	4	-	4
		f	c	2	2	4
	751-900	f	c	2	2	4
	901-950	f	c	2-1/2	2	4-1/2
	951-1050	f	c	3	2	5

TABLE 3.--Thickness of insulating tape, Mil. Spec. MIL-I-15349, for 1/4 and 3/8-inch hot piping

Temperature range (degrees F.)	Thickness of tape (inches)
125-338	3/8
339-750	1

TABLE 4.--Thickness* of insulating materials for hot surfaces of machinery and equipment up to 850°F.

Temperature range (degrees F.)	Thickness (inches)	
	Asbestos felt MIL-I-15091, block MIL-I-2819, or mineral wool blanket MIL-I-2818	Insulating cement MIL-C-2861, Type B
125-338	1-1/2	1-1/2
339-388	2-1/2	2-1/2
389-500	3	3
501-750	3-1/2	4
751-850	4-1/2	5

*Does not include finishing cement

TABLE 5.--Thickness* of insulating materials for hot surfaces of machinery and equipment over 850°F.

Temperature range (degrees F.)	Thickness (inches)			
	Felt			Block
	Inner layer MIL-I-16411	Outer layer MIL-I-15091 Type A	Total	MIL-I-2819
851-950	2	3	5	4-1/2
951-1050	2	3	5	5

*Does not include finishing cement

TABLE 6.--Thickness of refrigerant insulation for piping

Pipe size (inches)	Temperature range (degrees F.)	Thickness (inches)	
		Molded cork MIL-P-876	Cellular glass HH-I-551
Up to 3/4	-20 to -1	2.60	2.75
	0 to 35	1.70	2.00
	36 to 50	1.20	1.50
1	-20 to -1	2.75	3.00
	0 to 35	2.00	2.00
	36 to 50	1.30	1.50
1-1/4	-20 to -1	2.75	3.00
	0 to 35	2.00	2.50
	36 to 50	1.30	1.50
1-1/2 to 2-1/2	-20 to -1	2.95	3.00
	0 to 35	2.40	2.50
	36 to 50	1.35	1.50
3 to 5	-20 to -1	2.95	3.00
	0 to 35	2.40	2.75
	36 to 50	1.35	1.50

TABLE 7. THICKNESS OF REFRIGERANT INSULATION FOR MACHINERY AND EQUIPMENT

Service	Temperature range (degrees F)	Thickness (inches) Corkboard HH-C-561	Cellular glass HH-I-551
Refrigerant	−20 to −1	6	6
	0 to 35	4	5
Chilled water	36 to 50	2	2

TABLE 8. THICKNESS OF ANTISWEAT INSULATION, MIL. SPEC. MIL–I–15091, MIL–I–16022, MIL–I–2781, and MIL–I–2819

Service	Temperature range (degrees F.)	Thickness (inches) for machinery and equipment	Nominal thickness (inches) for piping
Cold water	32 to 99	1–1/2	1

Part 4. Application of Thermal Insulation to Pipe or Tubing

39–31. TEMPERATURES FROM 750° TO 1050° F.

1. Piping systems with temperatures over 500° F. include superheated steam piping and Diesel exhaust piping. Thermal insulation pipe covering, per Military Specification MIL–P–2781 Grade III is used for services from 750 – 1050° F. and is described in paragraph 39–11. The thickness of pipe covering should be as shown in tables 2 and 3.

2. Single layer molded pipe covering is applied directly on the piping. Side and end joints should be tightly butted. Sections are securely fastened in place with 18-gage (0.049 inch diameter) nickel-copper, brass, or galvanized soft iron wire or metal bands. Use three loops or bands per length of insulating material on pipes up to and including 6 inches and four loops or bands on large pipes. The ends of the wire loops are fastened together to hold the insulating material tightly against the pipe. The wire ends are bent over and carefully pressed into the pipe covering to leave no projection. In double layer work both the longitudinal and circumferential joints of the second layer are staggered in relation to the first layer and both layers are secured as previously described.

3. Thermal insulating tape as described in paragraph 39–11 is specially suitable for small piping and where space conditions render awkward the use of molded covering. The tape also is suitable for bends. Tape for spiral wrapping should be wired at each 10 inches approximately. Tape for wrapping laterally must be wired at each end of every strip. The lagging should be asbestos cloth Federal Specification SS–C–466, brattice cloth Military Specification MIL–C–788 or tape or glass cloth or tape Military Specification MIL–C–20079.

4. *Bends.* Where bends are encountered in the piping, the sectional insulating material is cut or mitered as shown in Figures 39–1, 39–2, and 39–3 to fit neatly around the contour of the bend. Care must be taken to insure that each segment is securely fastened in place. All openings and crevices are filled with high temperature cement, Military Specification MIL–C–2861 or finishing cement Military Specification MIL–C–2908, troweled smoothly to a uniform surface. Sharp bends may be insulated with asbestos insulating felt per paragraph 39–11 overlaid with ½ inch of high temperature insulating cement of finishing cement Military Specification MIL–C–2908 finished off smoothly.

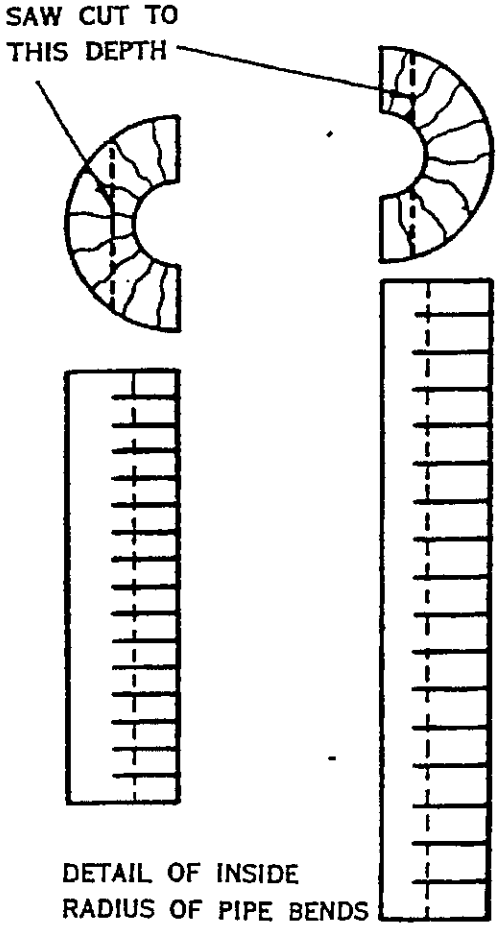

Figure 39–1.—Detail of outside radius of pipe bends.

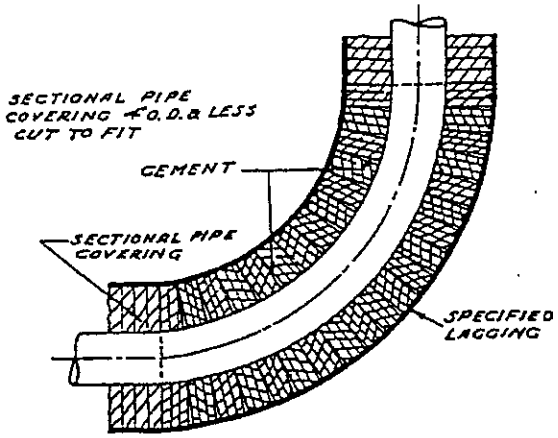

Figure 39–2.

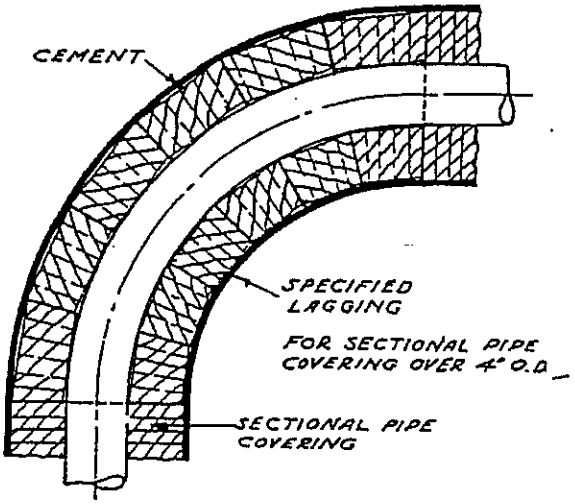

Figure 39–3.

39–32.

1. *Application of glass cloth and tape.* Glass cloth per paragraph 39–12 is fitted on tight and smooth and sewed with fibrous glass sewing thread using a single stitch, three to the inch. Glass cloth and tape may be cemented on with adhesive cement per paragraph 39–13. In general, tape rather than cloth is used for lagging pipe bends. Fibrous glass tape is applied in a spiral wrapping around the pipe. At the start the tape may be stapled to the insulating material or secured with an adhesive. On straight runs, a ¼-inch lap is sufficient. The tape may be furnished with a stripe woven in as a guide for lapping. On bends, the lap should be made at right angles to the axis of the pipe. A new roll of tape is started as if it were to be wrapped in the reverse direction and attached with staples or adhesive. The tape then is brought back over the fastening which thus is concealed from view. Where pipes are located close together, the tape may be applied easily by wrapping it on a smooth rounded edge metal "shuttle". The tape is fastened to the insulating material and the shuttle passed between the pipes, picked up on the far side, and the tape pulled tight.

2. *Application of asbestos cloth.* Asbestos cloth is fitted on tight and smooth. It may be sewed with asbestos yarn or may be cemented on. Cements described in paragraph 39–13 are suitable for asbestos cloth except for asbestos glass combination. The surfaces to be joined must be dry and clean. Apply the adhesive to the cloth, not to the insulating material. The more rough and porous the surface may be, the more adhesive will be needed. The cloth should be soaked in the solution and the insulating material given a liberal painted coat of the same. The lagging is applied while the surface is still wet.

39–33. DIESEL ENGINE EXHAUST FLEXIBLE CONNECTIONS

1. The connections may be insulated by one of the following methods:

a. In accordance with paragraph 39–31 provided the flexible connection is covered with 1-inch galvanized wire mesh before application of the insulating material.

b. Apply asbestos insulating felt per paragraph 39–11 overlaid with a layer of asbestos cloth. Lag in accordance with paragraph 39–31.

39–34. BULKHEAD EXPANSION JOINTS

Continue the insulation under the connection with the pipe covering butting each side of the flange which secures the joint to the piping.

39–35. PIPE HANGERS

Where pipe hangers are clamped around the piping, the sectional pipe covering may be stopped at the clamp and the space filled with layers of asbestos felt per paragraph 39–11 to the thickness of the covering. A single layer of asbestos cloth which extends over the sectional covering 2 inches on either side is wrapped circumferentially over the felt and is secured by wire through rings and hook fasteners to form a take-down seam. A similar covering may be used on flanges to which are welded anchor lugs for pipe hangers. Hangers may also be insulated by fitting the molded pipe covering as necessary; use insulating cement to complete the installation.

39–36. TEMPERATURES FROM 501° TO 750° F.

1. For temperatures between 501° and 750° F., thermal insulation pipe covering, Military Specification MIL–P–2781, classes c or d may be used. The thickness of pipe covering should be as shown in tables 1 and 2. This material is applied in the manner described in article 39–31. Lagging may be in accordance with paragraph 39–32.

39–37. TEMPERATURES FROM 165° and 500° F.

1. For temperatures between 125° and 500° F., thermal insulation pipe covering, Military Specification MIL–P–2781, class b, described in paragraph 39–11 is used. Lagging may be in accordance with paragraph 39–32. The thickness of the pipe covering should be as shown in tables 2 and 3.

39–38. COLD WATER AT ALL TEMPERATURES

1. Three insulating materials may be used on cold water pipe or tubing.

2. Asbestos insulating felt should be applied to thoroughly cleaned and dried pipe surfaces in the thicknesses shown in table 8. The material is described in paragraph 39–11.

3. The felt is applied in ¾-inch layers which are compressed to ½-inch thickness by 18-gage nickel-copper, brass, or galvanized soft iron wire wound on about 1 inch centers. Joints in adjacent layers of felt are staggered longitudinally and radially. Water-repellent asbestos felt in strip form is applied longitudinally; the width is such as to enclose the circumference of the pipe. The following table gives pipe sizes and widths of felt which have been extensively used for these sizes:

Width (inches):	*Pipe sizes (inches)*
6	½ and ¾
8	1 and 1¼
10	1½ and 2
14	2½ and 3
17	3½ and 4
20	4½, 5, and 5½

4. The asbestos felt is covered with one layer of water-repellent and flameproof sheathing paper which is described in paragraph 39–12. The paper should be tightly wrapped and lapped 3 inches each way. On bent piping the sheathing paper is mitered and fitted tightly. Joints must be sealed completely with adhesive cement Military Specification MIL–C–3316. The lagging may be asbestos cloth per paragraph 39–32 or glass cloth per paragraph 39–32. The lagging should be cemented on with material per paragraph 39–13.

5. Molded-asbestos pipe covering (Spec. MIL–P–2781), which is described in paragraph 39–11, may be used for cold water lines if felt is not available. Apply sheathing paper and lagging in accordance with paragraph 39–39.

39–39. REFRIGERANT

1. Molded cork pipe covering described in paragraph 39–11 is used in the thicknesses shown in table 6. See article 39–39 for other materials suitable for refrigerant at temperatures of 36° F. and over.

2. At the time of installation, the fire-retardant vapor seal may be applied to the cork in the following manner: The inner surfaces of the semicylindrical sections of cork are heavily coated with the compound by brushing and allowed to dry at room temperature for 24 hours. The longitudinal surfaces and ends of each section of the covering are then coated with the compound and the sections are immediately installed, butted together longitudinally, and secured. In the installation of the sections, excess compound which is forced out of the longitudinal joints may be doctored off. The external surface of the covering is then given a brush coat of the compound which is allowed to dry for 48 hours.

3. Pipes must be free from rust and moisture before applying insulation. Sectional covering, should be applied with end joints broken by starting with one half-and one full-length piece. Longitudinal joints should be at the top and bottom of the pipe. Wire the sections in place with at least six copper-clad wires per 36-inch section. When the pipe passes through an insulated wall into a refrigerated room, the pipe covering should extend into the room 1 inch beyond the wall. Pipe bends are insulated by mitering regular sectional covering to fit the bend, using pieces small enough to give approximately full contact between the pipe and the covering. Pipe hangers must be on the outside of the covering and not in contact with the pipe. Frost will collect around the supporting rod of a hanger attached directly to the pipe and will eventually work under and split off the covering at that point. A 12- to 18-gage galvanized sheet-steel shield should be used between the hanger and covering where the pipe rests in the hanger. The shield should extend at least 3 inches on each side of the hanger. Glass or asbestos cloth or tape lagging should be applied in accordance with paragraph 39–32.

Part 5. Application of Thermal Insulation to Valves, Fittings, and Flanges

39–51.

Permanently insulated valves and fittings should be covered to the same total thickness as the adjacent piping. Valves and fittings which are welded into the line are insulated permanently. Flanged valves and flanged fittings may have permanent or removable type insulation. Where the pipe covering is terminated at flanges, provision must be made for removal of the flange bolts or bolt-studs. The pipe insulation may be stopped off squarely and a short removable section of insulating material of sufficient length to permit the withdrawal of the bolting may be inserted. A less desirable method is to omit the short removable section of insulation by terminating and beveling off the pipe covering at the necessary distance from the flange.

39–52. COVERS

1. Readily removable and replaceable covers should be provided on the following piping elements requiring insulation:

a. Flanged joints (except valve bonnet joints) on all sizes of main and auxiliary steam piping carrying steam having a total temperature of 389° F. (205 p. s. i. saturated steam) and over, including flanged joints on all root connections and root valves thereon, such as valve bypasses, drain connections, pressure gage connections, etc.

b. Flanged joints on piping and adjacent to machinery units which must be broken when these machinery units are opened for inspection and overhaul, such as steam exhaust connections, feed pump suction and discharge connections, steam drain connections, etc.

c. Valve bonnets on all valves over 2 inches in size, working pressure of 300 p. s. i. and over, carrying fluids 240° F. and over.

d. Pressure reducing and pressure regulating valves, pump pressure governors, and strainer bonnets.

39–53. METHODS OF MAKING COVERS

1. Readily removable and replaceable covers for piping elements are made by the following methods:

2. Rigid covers made in two halves filled with asbestos felt are shown in figures 39–4 and 39–5. Covers are sewn and quilted with wire inserted asbestos yarn Federal Specification SS–C–466 Type II in such a manner as to provide a uniform thickness. Wire inserted asbestos cloth Federal Specification SS–C–466 Type I Grade C is

used on the inside of the covers to provide strength and rigidity. Asbestos cloth Federal Specification SS-C-466, Type I Grade B is used on the outside surface of the cover if the temperature of the insulated surface does not exceed 500° F. For temperatures over 500° F. asbestos cloth Federal Specification SS-C-466 Type I Grade D is used on the outside of the cover. Flexible asbestos millboard, 1/8 inch thick, is inserted between the asbestos felt and the asbestos cloth so as to retain the cylindrical shape of the cover. Hard asbestos millboard, 1/4 inch thick, enclosed in asbestos cloth of the type used on the outside of the cover is sewn on the ends of the cover. Where the flange diameter is larger than the outside diameter of the adjacent pipe-covering, build-up pieces are made of asbestos felt encased in asbestos cloth Federal Specification SS-C-466 Grade D, secured by stitching to the inside of the cover. The halves of the cover may be fastened around the equipment by means of 1/16 inch diameter soft galvanized iron rope laced through brass or galvanized steel hooks or rings, or covers may be secured by snap fasteners. Fastenings fixed to cloth lagging must be backed up by washers on both sides of the cloth.

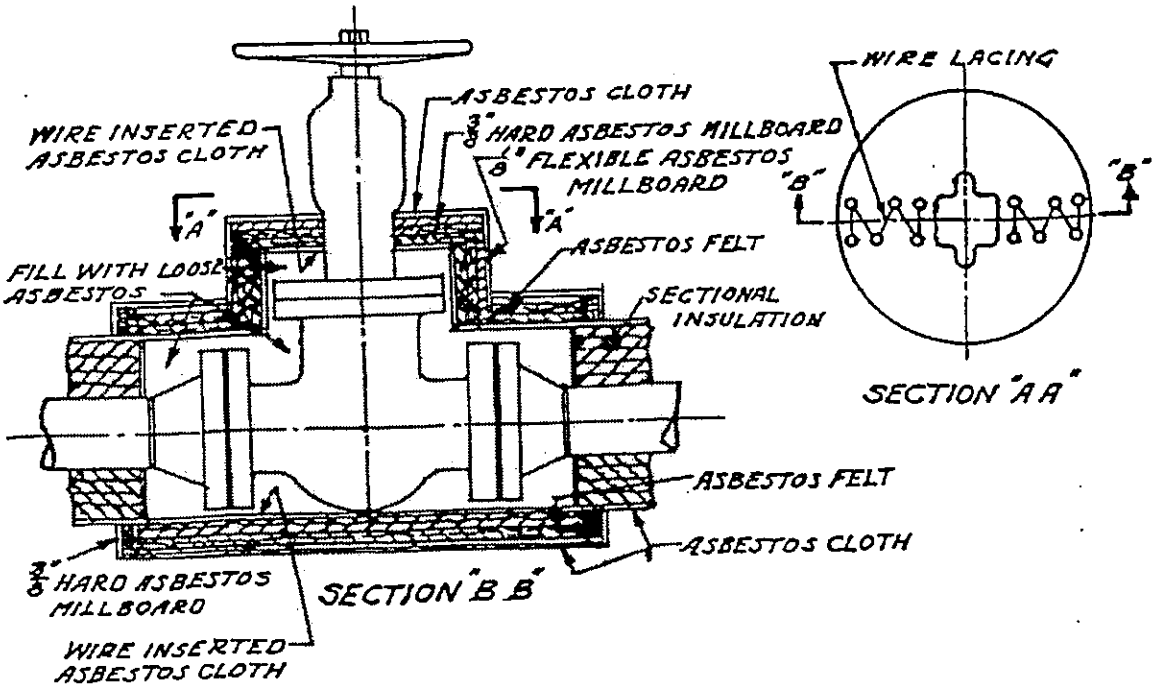

FIGURE 39–4

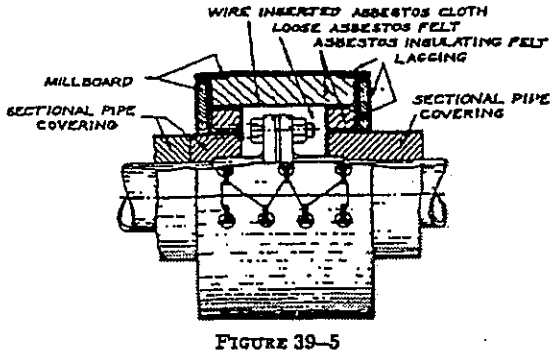

FIGURE 39–5

3. A rigid cover made up of segments of block insulation of the same material used for pipe covering is shown in figure 39-6. Block is securely wired to frames of ½ inch square mesh of 18 gage (0.049 inch diameter) galvanized steel wire. The wire mesh frames inside and outside of the block insulation have the ends bent over and joints secured with 18-gage, black-annealed, iron wire woven through the mesh. Insulating cement of the same material as the blocks is trowelled smoothly over all surfaces of the mesh. Asbestos roll fire felt Military Specification MIL-F-20077 may be used to build up the cover where the flange diameter is larger than the outside diameter of the adjacent pipe-covering. Covers should be lagged with asbestos cloth Federal Specification SS-C-466 Grade D tightly and smoothly fitted to envelop the outside and ends. Where double layer insulation is used, the two sections of the cover should be fitted together with a scarfed joint. Care must be taken in the workmanship to insure straight and true jointing surfaces of the sections with the view of reducing the heat loss at the joints. Bands and eyelets of galvanized steel are used for securing the cover around the equipment.

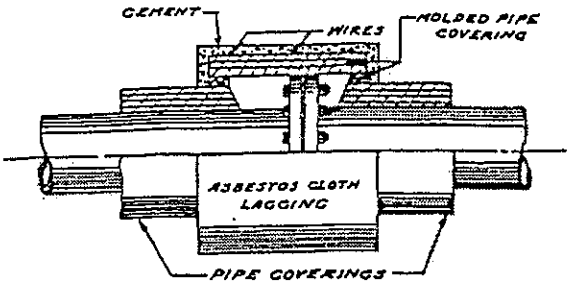

FIGURE 39–6

4. Rigid covers similar to those described in paragraph (2) above may be made of fibrous sectional pipe-covering (Military Specification MIL-P-2781) of the same thickness as that on the adjacent piping. The pipe-covering is strong enough so that the wire frames are not required.

5. Where the rigid covers described above are not practical, for example because of restricted space, flexible covers, as shown in Figure 39–7, may be used. These covers are similar to those described in paragraph (1) above except that the millboard is omitted.

e. The pieces of cloth are sewn together before filling with asbestos felt as much as it is practical to do so. Stitching is done from the inside where possible in order to improve the external appearance.

f. Before filling the cover with asbestos felt, a 3/16-inch diameter steel rod is inserted along the entire length of the outside lap of the joint. The rod is secured in place by stitching with asbestos sewing thread. This rod provides a straight hard edge at the outside of the lap, thus providing a greatly improved appearance and serving to hold the shape.

g. A stiffener strip, which consists of asbestos cloth of the same type used for the outside covering, is placed under the outside covering; its width should extend far enough to include the lacing washers and rings. The strip is well soaked in silicate of soda or adhesive cement and allowed to dry prior to insertion in the cover. The strip will be reasonably rigid but flexible enough to bend to the curvature of the cover. This piece of cloth serves to stiffen the surface of the cover in way of the lacing rings, washers, and wire and eliminates the corrugations caused by them.

h. The overlap is made to reduce the heat loss at the joint. It allows additional flexibility for drawing the

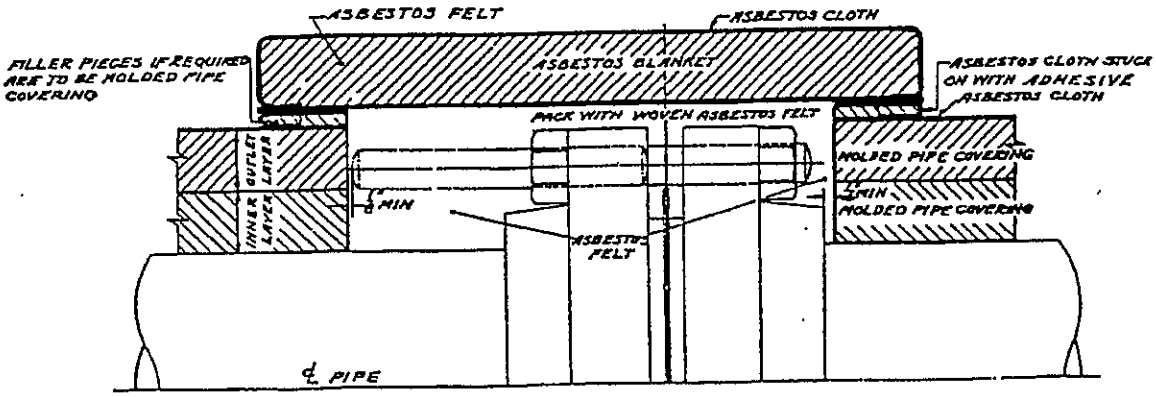

FIGURE 39–7

6. Flexible flange covers shown in figure 39–8 may be made as described below:

a. A circular wooden form is first made up with a diameter equal to the flange diameter for which the particular cover is going to be made.

b. The inner and outer covering of the flange covers are made of asbestos cloth. The inner cloth is laid over the form and accurately cut to the length required with allowance for stitching so that the finished inside surface will be smooth and free from wrinkles.

c. The end pieces of the cloth are cut circular to suit inside and outside diameters with the necessary allowance for stitching. The cloth cut in this form will eliminate puckers and wrinkles.

d. The outside cloth covering is cut in the same manner as described in (b) above.

ends of the cover together and provides a margin to take care of any difference in diameter that may occur.

39–54.

Spaces between removable covers and the surfaces they insulate should be packed with pieces of asbestos felt to exclude all air possible. On covers which do not fit tightly about the adjacent pipe covering, spaces should be calked with suitable material such as narrow strips of asbestos cloth.

39–55.

The foregoing description of the use of removable covers is applicable to the latest construction. Existing installations need not be changed simply to conform to these requirements but changes made only when replacement is necessary.

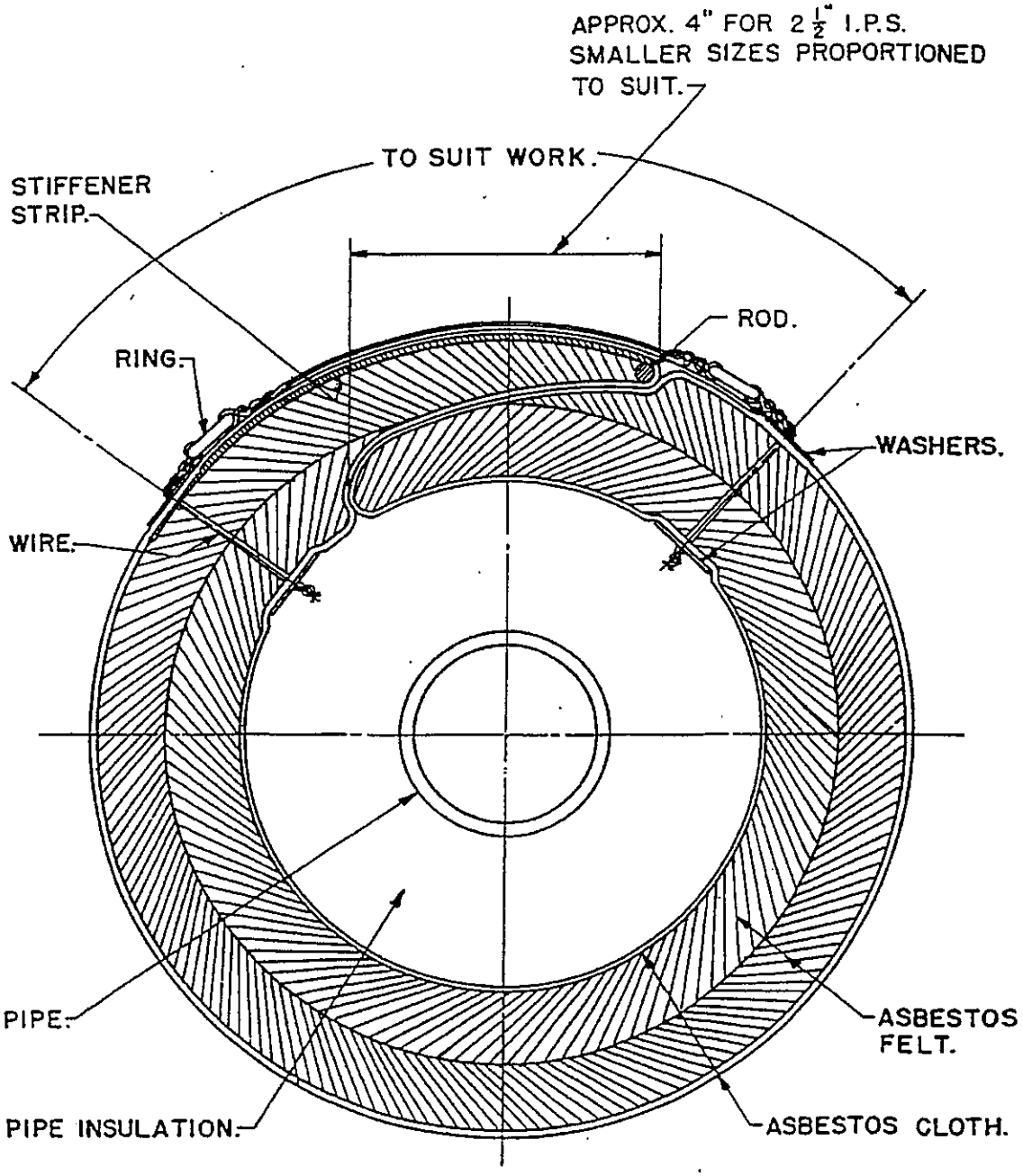

FIGURE 8

39–56.

1. Valves, fittings and flanges not included in article 39–52 may have permanent insulation; the following applies to temperatures of 125° F. and up:

a. For sizes 3½ inches and under, an all cement insulation may be used. Apply insulating cement, usually in accordance with MIL–C–2861, Type B, in ½ to ¾ inch thick layers to cover the bodies, flanges, and bonnets. Each layer of cement must be permitted to dry before the next is applied. Heat should be applied from within as soon as practicable and within 24 hours after installation of the cement to dry out the insulation and avoid corrosion of the metal. After drying, a coating ½ inch thick of high temperature cement tempered with Portland cement or equal (4 parts cement to 1 part Portland cement) or a coating of asbestos finishing cement per Spec. MIL–C–2908 is applied and trowel-rubbed to a smooth finish. Lagging should be in accordance with paragraph 39–12.

b. A method similar to that of paragraph (a) above but having a form of wire-reinforced asbestos cloth, Federal Specification SS–C–466 Grade C, over which the cement is applied is shown in figure 39–9. Spaces around the bolts should be packed with asbestos felt.

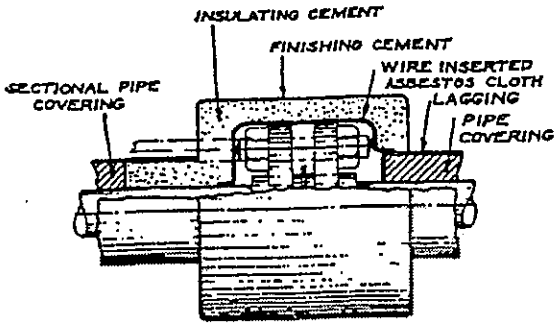

FIGURE 39–9.

c. All sizes may be insulated by cutting asbestos felt, Military Specification MIL–F–15091, in suitable widths and building up the thickness required to match the adjoining pipe covering allowing for ½ inch of finishing cement. On valves and fittings the felt should be carried over the flanges to the end of the sectional pipe covering. Spaces that cannot be filled with the layers of material should be completely filled with loose asbestos felt. Fix the first layer of asbestos to the metallic surface with adhesive cement, preferably of the type described in paragraph 39–13. Layers of felt are secured in position with black or galvanized iron wire and overlaid with 1-inch-square wire mesh. A ½-inch layer of cement as described in paragraph (a) above is applied. Lagging should be in accordance with paragraph 39–12. See figure 39–10.

39–57.

Valve bodies and fitting bodies may be permanently insulated as described in paragraph 39–56 but the felt is not carried over the flanges; the latter are insulated with removable covers.

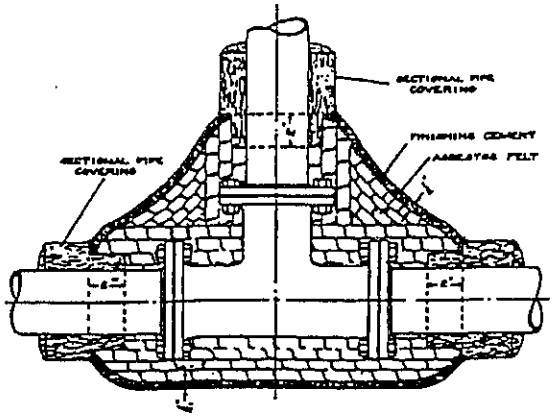

FIGURE 39–10.

39–58. COLD WATER AT ALL TEMPERATURES

1. Valves, fittings, and flanges for cold service do not have removable covers because the insulation must be tight against the penetration of moisture. The following methods are used:

a. Insulate in a manner similar to that described in paragraph 39–56 using either plain or water-repellent asbestos felt per Military Specification MIL–F–15091. Wire should be galvanized. Felt need not be covered with finishing cement. Place a layer of water-repellent and flameproof sheathing paper, which is described in paragraph 39–12, over the felt; paper should be mitered, lapped, and fitted carefully. Use adhesive cement, Military Specification MIL–C–3316 Type II, to secure and seal the paper. Lagging should be the same as used on the cold pipe; see paragraph 39–39.

b. Insulate as described in paragraph (a) above but use mineral wool pipe covering instead of asbestos felt.

39–59. REFRIGERANT

For temperature of 36° F. and over the methods described in articles 39–58 or molded cork may be used. Below 36° F. molded cork valve, fitting, and flange covers must be used for insulating refrigerant lines. Covers should be of the same thickness as adjacent pipe insulation. For the most generally used sizes, valve and fitting covers are furnished in two sections. The method of application outlined in paragraph 39–40 is used. Sections of cork covering made for pipes should not be mitered to form makeshift covers for flanged elbows or other fittings. Flanged fitting covers are applied after covering has been installed on the piping and rest upon the outside of the pipe covering. For other than flanged fittings, the covers are wired on first and the straight pipe insulating material is wedged in tightly between the fittings. To make the cork fit properly, cut the straight pipe covering rather than the fitting covers. Make cuts square to secure tight joints. Carefully wire the covers in place using not less than four 12-gage, copperclad, steel wires for each soldered fitting, and not less than six wires to each flanged fitting. Cement filler and putty used in commercial application of cork insulation must not be used because such materials are flammable.

Part 6. Application of Thermal Insulation to Machinery

39–71. RECIPROCATING ENGINES

1. Propulsion reciprocating engine steam cylinders, valve chests, and other steam enclosing surfaces are insulated with 85 percent magnesia or asbestos blocks which are described in paragraph 39–11. Insulation thickness shall be as shown in table 4. The blocks should be carefully fitted to the metallic surface. Where there are two layers, all joints should be staggered. The blocks should be firmly fastened in place with 1/8-inch galvanized steel cables spaced on 9-inch maximum centers. One-inch mesh, galvanized, wire netting of 18-gage wire is then spread over the surface and held by wiring to the steel cables. All joints should be neatly pointed with high temperature insulating cement per paragraph 39–11, and a layer of ½ inch finishing cement to cover the netting and tie wires completely trowelled on smoothly. Cylinders and valve chests are neatly lagged all over with 24-gage, galvanized, sheet steel per paragraph 39–12. Upper cylinder heads are insulated as described above but are arranged with cast-iron plates with nonslip upper surfaces instead of sheet-metal lagging. Metal lagging may be secured by using lap joints with a bead on the exposed edge, fastened with hardened self-tapping screws making their own thread in punched holes.

2. Auxiliary reciprocating engines may be insulated as described in paragraph 39–71. Asbestos felt per paragraph 39–11 may be used in place of blocks if it is considered more practicable.

39–72. TURBINES

1. All surfaces of propulsion and auxiliary turbines which have a maximum operating temperature of 125° F. or more should be insulated by one of the methods described in this section. Thickness of insulating material should be as shown in table VI.

a. Surfaces which can be permanently insulated may be covered with sufficient layers of asbestos felt per paragraph 39–12 to make up the required thickness. Joints of adjacent layers should be staggered. Layers of felt may be held to one another with adhesive cements per paragraph 39–12. Felt should be firmly secured with 1/8-inch, flexible, galvanized, steel cable spaced on 9-inch maximum centers around the outside layer. The cable may be fastened to steel hooks welded to the casing where required. No holes should be drilled in the casing. One-inch mesh netting of 18-gage, galvanized, steel wire is spread over the felt and secured by 18-gage wire to the cables. A ½-inch thick coating of finishing cement Military Specification MIL-C-2908 or of insulating cement MIL-C-2861 tempered with Portland cement or equal (4 parts insulating cement to 1 part Portland cement) is applied over the netting and trowel rubbed to a smooth finish. After drying 24 hours, an adhesive insulation cement per paragraph 39–12 is applied to the hard cement finish and allowed to dry for 1 hour, after which a second coat of the same cement is applied and allowed to dry. Lag the insulation with glass cloth or asbestos cloth of the correct type indicated in paragraph 39–13. Galvanized steel rings backed up by galvanized steel washers fastened on both sides of the lagging should be attached to the permanent insulation

adjacent to removable blankets. These blankets are used to cover the flange joint between the upper and lower casings. They are formed by quilting layers of asbestos felt together with fine nickel copper alloy or brass wire or asbestos twine per paragraph 39–12. The turbine side of the blanket is covered with wire-inserted asbestos cloth and the outer surface is covered with plain asbestos cloth of the type recommended.

2. Blankets are secured to the permanent insulation with 18-gage, galvanized iron or copper wire laced through metal hooks or eyes attached to the edges of the blankets and the rings on the permanent insulation. It is preferable that blankets should project well over the insulation of the adjacent surface. Blankets should be shaped to fit accurately, and spaces between them and the hot metallic surfaces should be completely filled with loose asbestos. (See fig. 39–11.)

3. Another method is to use the same procedure outlined in paragraph (1) above with mineral wool blanket insulation per paragraph 39–11 instead of asbestos felt for both permanent and portable insulation. Removable blankets made with mineral wool should be covered with ¼-inch of asbestos roll felt per paragraph 39–11 previous to enclosing them with asbestos cloth.

4. Thermal block insulation per paragraph 39–11 may be used for permanent insulation. Prior to applying the block, all irregularities of the turbine surface should be filled to form a smooth surface with high temperature cement. Insulation cement should be used to point up joints between the layers of block and all crevices should be filled. The block covering is held in place by 1/8-inch, flexible, galvanized steel cable spaced on 9-inch maximum centers. The cable may be fastened to steel hooks welded to the casing where required. One-inch mesh netting of 18-gage, galvanized steel wire is spread over the outer layer of block and secured by 18-gage wire to the steel cables. Finishing cement and lagging are applied as described in paragraph (1) above. Removable insulation also is the same as outlined in that paragraph.

5. High-temperature insulating cement, as described in paragraph 39–11, is sometimes used to form the complete permanent insulation. It is applied in layers less than 1 inch thick and is reinforced with wire mesh. Each layer must be permitted to dry thoroughly before applying more cement. Finishing cement and lagging are applied as indicated in paragraph (1) above. Removable insulation is the same as outlined in that paragraph.

39–73. BOILER STEAM DRUMS, WATER DRUMS, AND HEADERS

1. For insulation of boiler casings and refractory linings see chapter 51. See table VI for thicknesses of insulation.

2. Drum shells may be covered with sufficient layers of asbestos felt per paragraph 39–11 to make up the required thickness. The method described in paragraph 39–72 (1) should be followed. Figures 39–12 and 39–13 show a typical installation including the manhole cover of asbestos felt enclosed in a container made of 16-gage sheet metal per paragraph 39–11. Sometimes metallic lagging of 20-gage, galvanized sheet steel is used in lieu of asbestos cloth, as shown in Figure 39–14. The sheet steel is fastened with ¼-inch machine screws to ¼-by 1-inch flat bars

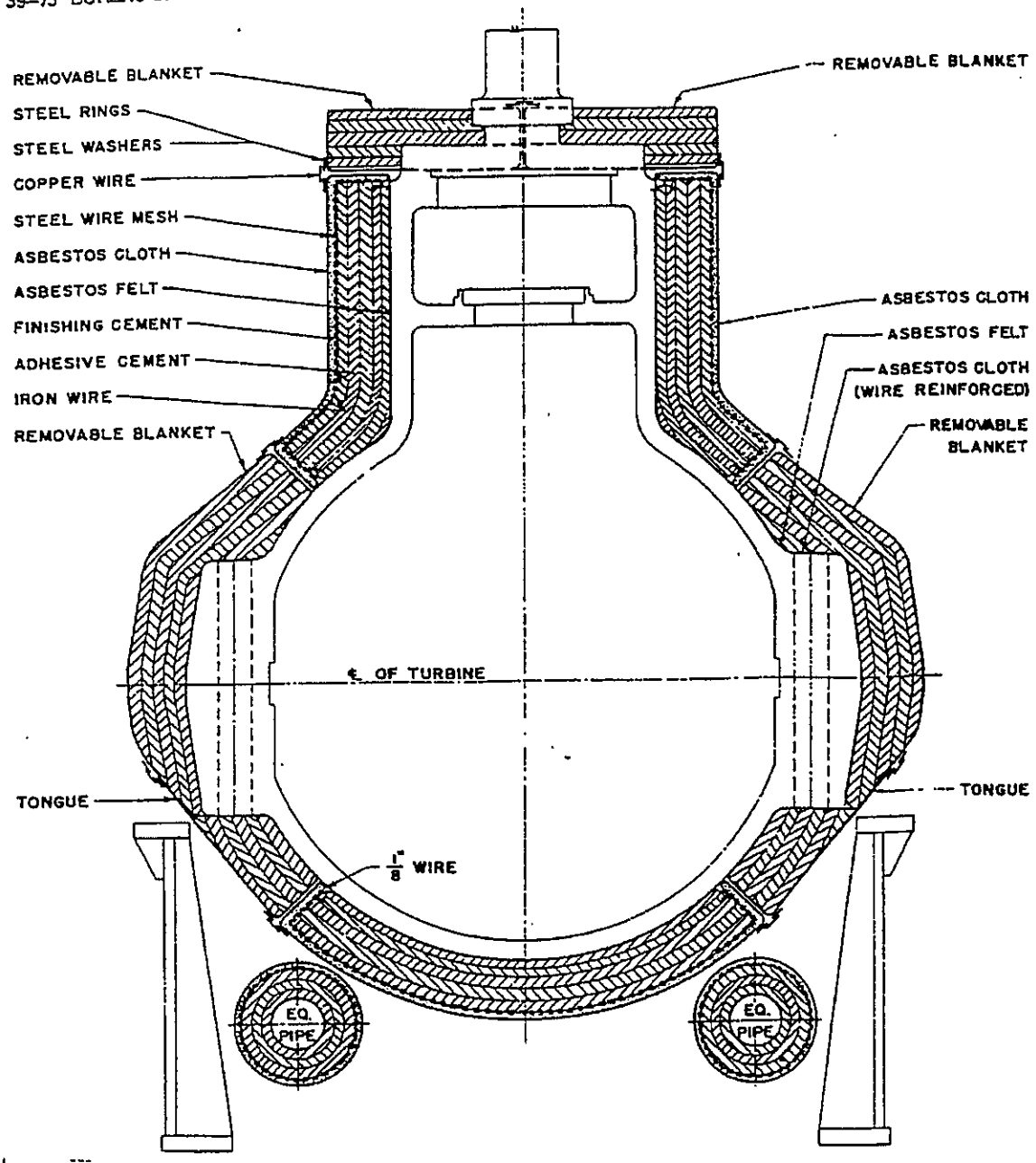

Figure 39–11.

bent to a suitable radius and imbedded in the finishing coat of cement.

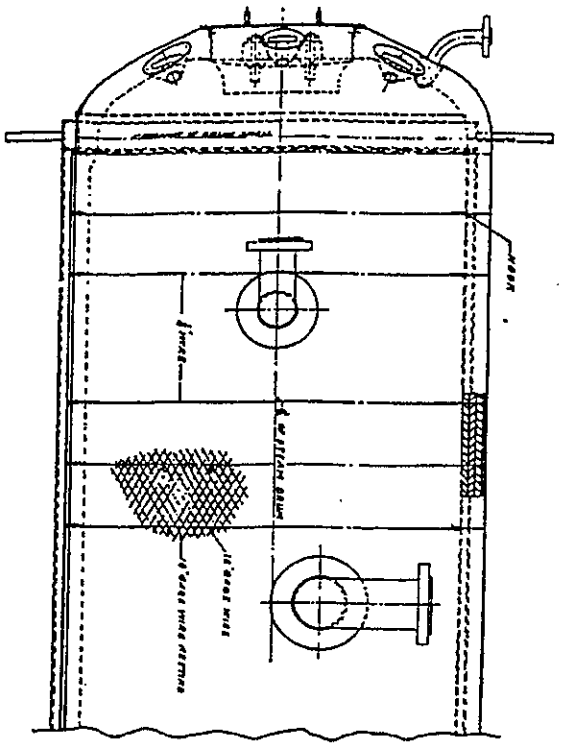

Figure 39–12.

3. Another method is to follow the procedure outlined in paragraph (1) above, but using mineral-wool-blanket insulating material per paragraph 39–11 instead of asbestos felt. The type secured between 1-inch wire mesh and expanded lath should be used; the latter side should face outward. The drum ends may be insulated with high-temperature insulation cement of the rock or mineral-wool type described in paragraph 39–11. Each layer of cement should be between ¾ and 1 inch thick and allowed to set for 24 hours or till dry. The manhole cover and the lagging should be of the type described in paragraph (1) above.

4. Block insulation may be used for drum shells. Materials are described in paragraph 39–11. Also large-size segmental pipe covering may be used. Application of this type of insulating material is outlined in paragraphs 39–71 and 39–72. The drum heads may be insulated with asbestos felt as described in paragraph (1) above or with cement as described in paragraph (2) above.

5. Superheater headers may be insulated with custom-made blankets of asbestos felt enclosed in asbestos cloth. These blankets are laced to studs welded to the superheater support plate. Downcomer tubes and soot-blower piping should be insulated in accordance with part IV covering pipes and tubing.

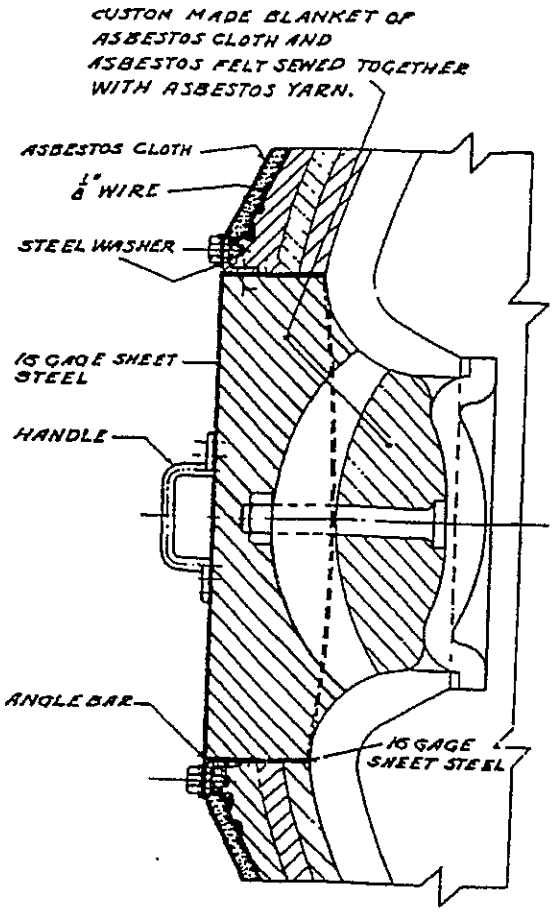

Figure 39–13.

39–74. UPTAKES

1. Uptakes and breechings are constructed with an inner and outer casing between which the insulating material is placed. Glass fiber batts described in paragraph 39–11 may be used. It may be secured in place by wiring it to T bars which are suitably spaced and attached to the inner casing. Also it may be secured by impaling it on studs used to support the outer casing. Washers made of asbestos millboard per paragraph 39–12 may be placed on the studs to hold the batts in place until the outer casing is installed.

2. Mineral wool blanket insulation per paragraph 39–11 (15) also may be used for insulating uptakes. It should be wired in place with separate pieces butted closely together.

39–75. LOW PRESSURE DISTILLING PLANT

1. The evaporator shells and the upper half of the evaporator ends, the vapor feed heaters, and air ejector condensers are permanently insulated with asbestos felt and cement with lagging in the manner described in paragraph 39–72. The lower half of the evaporator ends should

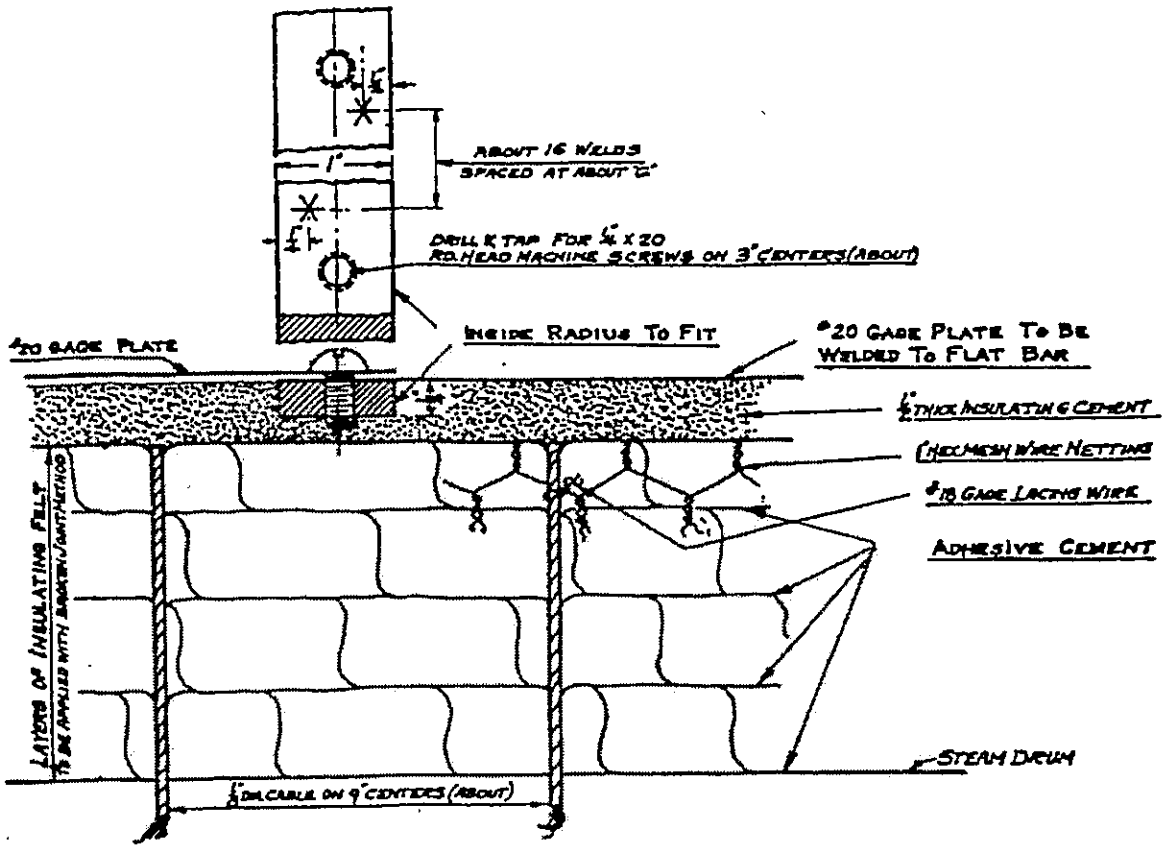

Figure 39–14.

be covered with removable asbestos felt blankets of the type discussed in paragraph 39–72. Refer to table VI for recommended thicknesses of insulation. The removable blankets may be fixed to 22-gage, galvanized sheet steel covers made in sections to suit the installation. Sections are held together and to the evaporators with ¼-inch machine screws or self-tapping screws. The blankets are secured to the metallic lagging by 18-gage, galvanized iron, or copper wire through rings attached to the blankets and hooks welded to the steel lagging.

2. The condensate cooler should be covered as is required for cold water service. Use a 1-inch layer of asbestos felt and cement the same as on above apparatus. Over the cement apply one layer of water-repellent and flameproof sheathing paper with vapor seals as instructed in paragraph 39–39. Lag with asbestos or glass cloth.

SECTION II. THERMAL INSULATION AND ACOUSTICAL TREATMENT OF COMPARTMENTS AND DUCTS

Part 1. General

39–101. SCOPE

This section covers the utilization of thermal insulation and acoustical treatment on the structure of ships and their ventilation and air conditioning systems.

39–102. THICKNESSES

1. *Thermal insulation.* a. The rate of heat flow through a homogeneous insulation is in inverse proportion to the thickness. When installed, however, the insulation can no longer be considered as homogeneous since the structure to which it is secured and the air films on either side of the composite structure-and-insulation must be considered. Because of this, equal increments in the thickness of insulation do not yield equal reductions in rate of heat transfer. Practically, this consideration means that small variations of insulation thickness do not materially affect the rate of heat flow and therefore, the corresponding ventilation air volumes required. As a result, it has been possible to adopt uniform thicknesses of insulation for varying rates of heat transfer at different temperature levels. The thicknesses in general use are:

(1) *One inch.* For all spaces requiring insulation where exposed to the sea or weather, for insulated boundaries of air conditioned spaces, drying rooms, galleys, bakeries, pantries, sculleries, and spaces containing machinery or apparatus causing high temperature and subject to intermittent use, and for spaces where insulation is used as a fire retardant medium.

(2) *Two inches.* For the plane surfaces of insulated boundaries of spaces, such as enginerooms, firerooms and uptake spaces, and evaporator rooms, containing machinery or apparatus causing high temperatures and subject to constant use.

(3) *Minimum of six inches.* For refrigerated spaces other than 0°F. freeze rooms.

(4) *Minimum of nine inches.* For 0°F freeze rooms.

(5) *Three-quarters or one inch.* For ventilation and air conditioning ducts requiring insulation.

(a) Other thicknesses are installed to meet special conditions. As an example, on destroyer - type ships where weight is a primary consideration, 3/4-inch thick insulation has been used in lieu of 1-inch board. If there is any question as to the thickness of insulation to be installed when replacing insulation, the insulation plans for the vessel should be consulted. For new designs the thicknesses of insulation to be installed are specified in the detail specifications for the particular ship. In the absence of any specific instructions, the use of thicknesses given above is acceptable.

2. Acoustical absorptive treatment. One inch thick sound absorbing blanket - For ventilation and air conditioning ducts requiring acoustical absorptive treatment.

a. Two inch thick sound absorbing blanket - For compartments.

Part 2. Hull Thermal Insulation

39–111. APPLICATIONS

"Hull thermal insulation" is the term given to the insulation which is applied to the shell, bulkheads, overhead, and the structural members of these components of a ship's hull to differentiate it from the thermal insulation applied to equipment, refrigerated spaces, and ducts. The hull insulation is installed in the locations and thicknesses enumerated in Section S39–1 of the General Specifications for Ships of the United States Navy and in the detail specifications for the particular ship.

39–112. MATERIALS

1. Hull insulation used on naval surface ships and on certain boundaries of submarines consists of fibrous glass insulation board conforming to Military Specification MIL–742, Type I or Type II.

a. Type I insulation board consists of glass fiber impregnated with a binder and formed into a board, and faced with a layer of treated and hardened fibrous glass cloth which provides a rigid, damage-resistant surface.

b. Type II insulation board consists of glass fiber impregnated with a binder and formed into a board. It is not furnished with a cloth facing, but is faced during installation.

2. Fibrous glass tape used for covering the seams formed by the adjacent panels of Type I insulation board conforms to Military Specification MIL–C–20079, Class C, without resin treatment, and is secured to the insulation board with adhesive, Military Specification MIL–C–3316, Type II.

3. Cotton brattice cloth used for facing Type II insulation board conforms to Military Specification MIL–C–788

and is secured to the insulation board with adhesive conforming to Military Specification MIL–C–3004.

4. Types I and II insulation boards are attached to the ship's structure by use of studs conforming to Military Specification MIL–S–18109 and fasteners shown on Bureau of Ships Hull Standard Plan No. 805–1343696.

5. Vapor barrier coating compound, conforming to Military Specification MIL–C–19993, is applied over the exposed surfaces of fibrous glass hull insulation board installed on the warm side of refrigerated spaces boundaries and in drying rooms, where because of large difference in temperatures or high humidities, condensation is apt to occur.

6. Hull insulation used on submarines to insulate the pressure hull consists of compressed corkboard, conforming to Federal Specification HH–C–551.

7. High initial bond adhesive conforming to Military Specification MIL–A–18065, is used to secure corkboard to the pressure hulls of submarines.

39–113. INSTALLATION

1. The metal boundary, which is to be insulated, is inspected to determine that the protective coating is intact and the surface is free of any grease or dirt. Where necessary, the metal surface should be touched up as specified in Bureau of Ships Technical Manual Chapter 19. At the time the surfaces are inspected, measurements should be made of the structural members whose flanges and webs are to be insulated. Prefabrication of insulation into wrapping has been found to be the best method of covering structural members, since a minimum of cutting fitting is thereby required. The method consists essentially of cutting V grooves, properly spaced, removing the loose strips of board and then bending to shape for fitting around the flanges and webs. If type I insulation board is used to insulate the structural members, the kerf-cutting knives are adjusted to reach just below the cloth facing; if type II unfaced insulation board is used, the kerf-cutting knives are adjusted to reach to about 1/4-inch below the surface and thus the board is held together.

2. There are two acceptable methods for securing the board to the structure. In one, the studs are laid out and welded in place on the structure, with due regard to the number required and dimensions and contour of the section of board to be installed. The board is then impaled over the studs. In the other method, each section of board is first fitted into place, and locations of the studs determined by punching through the board to mark the metal. The board is then removed, the studs welded, and the board then slipped over the studs through the holes previously formed. In both methods, after the board is in place and pressed firmly against the structure, the fasteners are secured over the studs. Sufficient studs must be used to hold the board firmly and evenly against the structure. Welding of the studs and testing of the welds is to be done in accordance with Bureau of Ships Technical Manual Chapter 95.

3. When Type I faced insulation board is installed, fibrous glass tape is applied over the seams where the boards are butted together and secured to the board facings with adhesive conforming to Military Specification MIL–C–3316, Type II.

4. When Type II unfaced insulation board is installed, no tape is used over the seams. One full hiding coat of adhesive, conforming to Military Specification MIL–C–3004, is applied with a brush or trowel over the board. Cotton brattice cloth, Military Specification MIL–C–788 is applied over the board, lapped about 1 inch on intersecting surfaces, and pressed smooth. Another coat of the adhesive is applied over the cloth as heavily as necessary to fill all interstices of the cloth and to insure the adherence of the cloth.

5. Sheathing is not normally permitted over hull insulation board Type I faced board and Type II unfaced board faced with brattice cloth are tough and resistant to almost all forms of damage and, therefore, do not require any sheathing.

6. After the board is installed, it is painted to match the other surfaces in the compartment.

7. Vapor barrier coating compound, Military Specification MIL–C–19993, is applied in three brush coats of white, orange, and white in that order over the exposed surfaces of fibrous glass insulation board installed on the warm side of refrigerated spaces boundaries and in drying rooms. No holidays should exist in any single coat of vapor barrier coating compound.

8. Details of the installation thermal insulation in compartments are shown on Hull Type Plan BUSHIPS No. 805–1749057.

39–114. INSPECTION

Hull insulation should be inspected at least at semi-annual intervals together with other portions of the hull structure. Areas behind insulation on weather and sea boundaries of ships operating in cold waters (below 40°F.) and in ammunition spaces, where condensation is likely to occur, should be inspected during overhauls to insure that corrosion has not occurred on ship's structure. Action should be taken to have all damage, including that considered as minor, repaired at once since prompt repair will forestall development into major repair jobs.

39–115. REPAIR

1. Two procedures for repair of damaged fibrous glass insulation board have been established; one for accomplishment by ship's forces, and the second by qualified repair activities.

2. Each ship fitted with fibrous glass insulation board has an allowance of fibrous glass tape and type II adhesive for shipboard repair of small tears, dents, gouges, and similar damage to the insulation. Application of the tape will, in most instances, prevent further damage and insure the continued serviceability of the insulation until the next overhaul of the vessel when, if warranted, more extensive repairs can be made.

3. For extensive repairs to the insulation, in most instances the insulation may, in lieu of being replaced, be repaired economically with a resultant condition at least equal to that of newly installed board. The method, which is similar to that used to face type II unfaced board, is based on the fact that most damage occurs initially to the cloth surface, and leaves the body of the board relatively intact.

a. Before the cloth covering is applied, the damaged insulation is prepared as follows:

(1) Missing studs are replaced.

(2) Minor cuts, tears, and dents are repaired.

(3) Studs and fasteners are covered with small patches of cloth in order to provide a uniform foundation for the overall cloth.

b. After the damaged insulation has been prepared, cotton brattice cloth is cut to fit a suitable section of the area to be covered. A typical application would take a single piece of cloth from deck to overhead between structural members. The corresponding section of insulation is given a coat of adhesive, conforming to Military Specification MIL–C–3004, applied with either a brush or trowel, and the cloth is set in place and pressed smooth. A top coat of adhesive is then applied on the cloth as heavily as necessary to fill all interstices of the cloth and insure the adherence of the cloth.

Part 3. Antisweat Treatment

39–121. MATERIALS

For vermiculite paint materials and methods of application, see Bureau of Ships Technical Manual Chapter 19.

39–122. APPLICATIONS

1. Vermiculite paint is applied on the warm side of uninsulated boundaries, including webs and flanges of beams and stiffeners in the following locations:

a. Interior surfaces, including uninsulated flanges, of all spaces, except tanks, voids, and heat producing spaces, exposed to the sea or weather, or where sweating will occur because of opposite extremes in temperature.

b. Deck under and all vertical boundaries of air conditioned spaces common to spaces that are not air conditioned.

c. Exterior surfaces of water tanks in way of all spaces except voids.

d. Under surfaces of gravity cooling coil drain troughs and exteriors of cans used to collect cooling coil drainage.

e. Vermiculite paint is applied to hangers, brackets, clips, and other members secured to or penetrating boundaries exposed to the sea and where dripping will affect electric installations.

Part 4. Refrigerated Stores Spaces

39–131. APPLICATIONS

The refrigerated stores spaces are insulated in order that they may be maintained at the low temperatures required for proper preservation of the perishable foods carried. On all ships some built-in refrigerated stores spaces (as distinguished from household type refrigerators used in ships' pantries) are provided, although the number and size of the individual spaces vary from ship to ship. Typical refrigerated stores spaces are 30°F. chill rooms and 0°F. freeze rooms.

Although there are several types of refrigerated stores space construction, the standard construction used on most naval ships complies with hull type plans, Bureau of Ships Numbers S5904–860247, S5904–860248, S5904–860249, and S5904–860250.

39–132. MATERIALS

1. The construction of refrigerated stores spaces in accordance with the above plans involves installing insulation on all boundaries within the group of spaces and then lining the interiors of these spaces with metal sheathing. Insulation is fibrous glass insulation felt, Military Specification MIL–I–15475, fibrous glass insulation felt, Military Specification MIL–I–16022, Class 5, or mineral fiber insulation felt, Military Specification MIL–I–16688. Either corrosion-resisting steel, Federal Specification QQ–S–00–766, Class 430, 2B finish, or nickel copper alloy, Federal Specification QQ–N–281, Class A, cold rolled sheets, satin finish, may be used for the sheathing. The thickness of the ceiling and bulkhead sheathing is 0.0299 inch and that of the floor is 0.0747 inch. The minimum insulation thicknesses are 6 inches for outer boundaries of chill rooms, 9 inches for outer boundaries of freeze rooms, 4 inches on each side of structural bulkheads between refrigerated spaces, 6 inches on nonstructural bulkheads between refrigerated stores spaces, and 6 inches on the decks and 4 inches on the underside of decks between refrigerated stores spaces. Floor bearer supports and ceiling supports are made of laminated phenolic blocks, Military Specification MIL–P–3115 or MIL–P–17549, or compressed impregnated wood, Military Specification MIL–W–2872, to reduce the flow of heat from the structure to the sheathing.

2. All materials are of adequate strength to carry the heavy loads imposed on the sheathing when the spaces are filled with supplies.

3. All parts of the breather opening are composed of brass.

39–133. INSTALLATION

1. Installation of the component materials for the refrigerated stores spaces follows the details shown on the hull type plans listed in article 39–131. Special attention is given to the instructions for maintaining the watertightness of the completed lining and for insulating all the supporting structure from the ship's structure. All butts in floor plates are welded watertight by the step-back method, and the start and stop of each increment chipped and cleaned before the closing increment is laid.

2. Before the insulation and sheathing are installed, the structural bulkheads are tested for airtightness. Breather openings, as required in the plans, are installed high in the sheathing on each bulkhead and door of the refrigerated stores spaces. On bulkheads and doors forming the partition between two refrigerated stores spaces, the breather openings are installed only on the colder side of the partition. Label plates bearing the inscription, "Keep plug out except when defrosting, washing down, or air testing", are soldered on sheathing alongside each breather opening.

3. Sheathing supports and ship's structure behind sheathing are given two coats of red lead, Formula 116, in addition to the after pickling primer (see Bureau of Ships Technical Manual Chapter 19).

39–134. BREATHER OPENINGS

1. A considerable tendency (pressure) exists for the water vapor in warmer air to migrate to colder air. Whenever the temperature at any point within a partition becomes lower than the dew point of the air, condensation of the water vapor tends to occur at that point. In refrigerated stores spaces, the dew point is usually located somewhere in the insulation. The presence of water in the insulation is undesirable since it reduces the efficiency of the insulation.

2. The practical way of keeping the insulation dry is to construct the refrigerated stores spaces so that the resistance to water vapor flowing into the insulation is considerably greater than the resistance to its escaping. This is accomplished in spaces constructed in accordance with the hull type plans listed in 39–131 because the outer boundaries are practically airtight while openings are left in the interior vertical sheathing. Since the coldest air is at the coils, moisture in the insulation, if any is present, migrates through the breather openings to the coils.

3. The breather plugs are inserted in the breather openings when defrosting or washing down the spaces in order to seal the sheathing and prevent moisture entering the insulation and when conducting air tests to determine the tightness of both sheathing and surrounding structure. At all other times the plugs are kept out in order to permit the migration of moisture from the insulation.

39–135. INSPECTION

1. The sheathing should be inspected and tested periodically to ascertain that watertightness is being maintained at all seams and that the sheathing has not been punctured. All such defects should be repaired immediately, for, if the insulation is allowed to become water soaked, it will cease to be effective.

2. Deck drains should be opened periodically to determine whether water has penetrated sheathing and accumulated on the deck beneath.

3. Insulation should be checked as a possible source of trouble, due to becoming water soaked, if design temperature cannot be maintained.

39–136. REPAIR

1. The repair required will depend on the nature of the damage. When extensive deck repairs are indicated, the condition of the deck insulation should be ascertained by inspection. Holes 12 to 18 inches square are cut in the deck. Deck areas of less than 250 square feet require only one hole cut in the center; deck areas exceeding this figure require additional holes cut in the corners. If standing water or excessive moisture is found, leaks should be looked for and repaired. Then the insulation should be dried by blowing warm air through one or more inspection holes while venting through others. When the insulation is dry, the deck should be repaired. When repairs are made to the vertical sheathing, the bulkhead insulation is inspected to determine if the steel structure is corroded. Wet insulation is dried in a manner similar to that used for drying deck insulation.

2. If repairs are sufficiently extensive to require replacement, the spaces are to be restored in accordance with the original specifications.

39–137. OTHER REFRIGERATED STORES SPACE CONSTRUCTIONS

1. Minesweepers. Several types of construction are used on these ships.

a. Spaces are constructed in accordance with the hull type plans listed in article 39–131 except that nonmagnetic materials are substituted wherever ferrous materials, other than corrosion-resistance steel, are specified on the plans.

b. Spaces are built almost totally of wood except that for sanitary reasons the inner sheathing is corrosion resistant steel. The exterior boundaries are constructed of plywood internally framed and supported off the deck on 2-inch by 4-inch longitudinal beams. A vapor barrier such as asphaltic emulsion and asphalt paper is applied to the interior surfaces of all exterior boundaries. Fibrous glass or mineral fiber insulations are used in these spaces. Breather openings are provided in the inner sheathing bulkheads.

2. Refrigerator ships and other auxiliaries. Though construction varies, the following is representative:

a. Outer boundaries are steel. Bulkhead and overhead supports are generally 2 by 6-inch wood studding. Fibrous glass insulation fills the air space between inner and outer boundaries.

b. Interior sheathing is generally two courses of tongue and groove wood nailed normal to one another to the wood frame with Number 15 asphalt paper between courses. Breather openings are installed.

c. Decks are generally slab cork laid in several courses. Each course is asphalt coated. In way of hatches where added deck loading is expected layers of wooden sleepers or supports laid in a lattice-like fashion normal to one another, provide the necessary additional support.

d. For maximum water-tightness, a soldered lead pan is provided over the cork insulation and flashed 12 inches up all bulkheads. A 1–1/2-inch reinforced concrete surface is laid over the lead with a 1-inch mastic surface covering the concrete.

39–138. REPAIR OF MINESWEEPER AND AUXILIARIES REFRIGERATED STORES SPACES

1. Minesweepers. The degree to which the following repair measures should be done will depend on the condition of the space and ship's structure.

a. Where the outer boundary is ship's structure and space is available, the compartment should be rebuilt so that air is free to circulate around all boundaries of the box. This may mean rebuilding to provide external boundaries and supporting the box off the deck. Rat proofing should be provided around all areas where rats might nest.

b. Where repairs require exposing the support framing, studding should be re-worked to permit free air circulation within the insulation. Where this would be helpful, vent holes about 3/4-inch in diameter should be drilled at about 24-inch center along the centerline of the framing. Breather plugs should be installed, one in each bulkhead and overhead or one for each large isolated air pocket.

c. Where soldered deck seams require repair, the solder should be removed and the seams welded to provide watertightness up all bulkheads a minimum of 18 inches. Care must be exercised in welding to minimize damage to wood supports.

d. Wood used for repair should be as specified below:

(1) A vapor barrier should be applied if possible on all exterior boundaries (liquid or foil type vapor barriers as approved by the Bureau should be used); where external boundaries cannot be covered, the inside of the external boundaries of the box should be covered with a barrier consisting of one spray coat of bituminous emulsion covered with a Number 15 asphalt paper covered with a final coat of bituminous emulsion.

2. *Auxiliaries and reefer ships.* A reduction of insulation efficiency of refrigerated spaces is generally due to wet deck insulation. The degree to which the following repair measures should be done will depend on the condition of the space and ship's structure.

a. When extensive deck repairs are indicated the condition of the deck insulation is to be ascertained by inspection. Holes 12 to 18 inches square are to be cut in the deck, the number and location of which will be determined by the size of the space. Deck areas of less than 250 square feet will require only one hole cut in the center; deck areas exceeding this figure, will have additional holes cut in the corners. If standing water or excessive moisture is found leaks should be looked for, repaired, and the insulation dried if feasible (a usual leak is a poorly fitting deck drain). It should be possible to dry fibrous glass or rockwool insulation by blowing warm air through one or more inspection holes while venting through others; it may not be possible, however, to dry cork insulated decks in this manner. Replace insulation when it is clearly evident that corrosion has endangered the integrity of the structure or when the wood sleepers have clearly decayed and replacement is necessary to provide firm support for floor loads. If the structure beneath wet cork insulation is not corroded, the deck may immediately be repaired. Coils or other apparatus originally supported on the deck should be supported on bulkheads or overheads where possible. Where support must pierce the deck insulation, the lead pan and overlaying deck materials should be flashed up about the support a minimum of 2 inches.

a. When repairs are made, inspect bulkhead insulation to determine if the wood or steel structure is corroded or decayed. Wet insulation is to be dried in a manner similar to that used for drying deck insulation.

b. Should repairs to these spaces be sufficiently extensive to require replacement, the spaces are to be restored in accordance with the original specifications. Wood used should have a moisture content of 10 to 15 percent and should conform to specifications listed below. Wood used may also be the same species as originally used but pressure preservative treatment should be as specified below:

Use	Wood	Grade	Preservative
Framing	Southern Pine Douglas Fir	No. 1 Dimension Construction	Spec. TT-W-571, Table III
Sheathing (under course)	Southern Pine T&G West Coast Hemlock T&G Douglas Fir T&G Plywood	No. 1 Boards Select Merchantable Construction MIL-P-18066, Cl. 1	do. do. do. MIL-P-19550
Sheathing (exposed course)	Southern Pine T&G	Industrial 72-50	No treatment
	Douglas Fir T&G	"C" Construction	do
	Plywood	Edge Grain MIL-P-18066 Cl. 3	
	West Coast Hemlock T&G	"C" Construction, Edge Grain	

1. Where treated wood has been cut in any manner, the exposed area should be treated by a heavy brush coating of preservative, Military Specification, MIL-W-18142, Type A or B.

2. Exposed sheathing should be given three coats of varnish, BUSHIPS formula 80.

3. Fire retardant cellular polystyrene blocks, Military Specification, MIL-P-16591, or cellular glass blocks, Federal Specification HH-I-551, may be used in lieu of cork.

Part 5. Thermal Insulation for Ducts

39–141. APPLICATIONS

1. Ducts are insulated to reduce transfer of heat between the air carried in the system and the surroundings, and to prevent condensation of moisture on the ducts. In general, supply trunks and ducts which carry unheated outside air are insulated where they pass through, or terminate in, hot or normally heated spaces. This is to prevent condensation on the outside of the ducts in cold weather and chilling of normally heated spaces, and, in warm weather, further heating of the atmospheric air before reaching the space it is intended to cool. Supply trunks and ducts carrying preheated (45° – 60°F.) air are insulated only where they pass through hot spaces. Supply ducts carrying reheated air (about 90°F.) are insulated only to prevent loss of heat where they pass through spaces other than the space served.

2. To prevent discomfort to personnel, ducts carrying reheated air are insulated only where they pass over tiers of berths in the space being served, provided that the difference between the design winter temperature of the space and the temperature of the reheated air is more than 20°F. Exhaust trunks and ducts from engine, boiler, and auxiliary machinery rooms are insulated where they pass through living and working spaces and passages to prevent overheating these spaces. All ventilation trunks and ducts are insulated where they pass through refrigerated or air conditioned spaces to prevent condensation within the trunk or duct and to reduce the heat load on the refrigerating plant. Housings of cooling coils and all ducts on the discharge side of coils of mechanical cooling systems are insulated. Ventilation heaters are insulated only when installed in the weather (to prevent heat loss), and where necessary in group berthing spaces (to prevent either overheating of the space or injury to personnel).

39–142. MATERIALS

1. Ducts are insulated with 1-inch thick fibrous glass insulation felt, Military Specification, MIL-I-16022, Class 5, 3/4-inch thick hard faced fibrous glass insulation board, Military Specification, MIL-T-742, Type I, or 3/4-inch thick unfaced fibrous glass insulation board, Military Specification MIL-I-742, Type II.

2. When fibrous glass insulation felt is used, it is covered either with fibrous glass cloth, Military Specification MIL-C-20079, secured with adhesive, Military Specification MIL-C-3316, Type II, or cotton brattice cloth, Military Specification MIL-C-788, secured with adhesive, Military Specification MIL-C-3004. When unfaced fibrous glass insulation board is used, it is covered with cotton brattice cloth secured with adhesive, Military Specification MIL-C-3004.

3. *Vapor barrier coatings.* When a vapor barrier is required, on duct insulation, the following coatings are used:

a. Vapor barrier coating, Military Specification MIL-C-19993, is used on fibrous glass cloth faced insulation felt or board.

b. Vapor barrier coating, Military Specification MIL-P-876, is used on cotton brattice cloth faced insulation felt or board.

39–143. INSTALLATION

1. Insulation is installed and lagged (covered) on ducts, where required, as shown on Hull Type Plan, BUSHIPS No. 805-1749058 and in accordance with the instructions below.

2. Ducts are insulated by applying adhesive on the underside of flat surfaces and other necessary locations, applying the insulation to the duct and tying the insulation in place with 0.049 inch diameter galvanized iron wire or fibrous glass thread, Military Specification MIL-C-20079. Then the insulation felt or the unfaced insulation board, if used, is lagged with fibrous glass or cotton brattice cloth, secured with the specified adhesive. If hard faced fibrous glass insulation board is used on the duct, the joints of the board are covered with fibrous glass tape, Military Specification MIL-C-20079, Class C, secured with adhesive, Military Specification MIL-C-3316, Type II.

3. To apply insulation to ventilation heaters, first cut the hard faced fibrous glass board in panels to fit all surfaces except the standing flanges, beveling the edges of the panels at 45° to permit access to the bolts in the flanges. Coat the surfaces to be insulated with cement and fit the panels to the coated surfaces applying sufficient pressure to insure adherence of the panel to the surface. All seams in the fibrous glass board panels are to be taped with 2 inch wide fibrous glass tape, Military Specification MIL-C-20079, Class C, applied with adhesive cement. To assist in holding the panels in place and to cover the exposed fibrous glass, the beveled boundaries of the panels are to be covered with 3-inch wide fibrous glass tape, leaving a 3/4-inch lap on the standing flange. No lagging

Naval ships. These include treatments for damping the vibration of ship's structures, "resiliently mounted room within a room" treatment for control spaces adjacent to high level noise sources, and audiometric testing booths for testing personnels' hearing. The details of the installation of these various treatments are covered by the detail specifications and working plans for the particular ship.

39–155. INSPECTION

The acoustical treatments should be inspected regularly to ascertain if any damage has been incurred. Action should be taken to have all damage, including that considered as minor, repaired at once, since the effectiveness of many acoustical treatments depend upon the maintenance of their integrity.

INDEX

Exhibit E

CODE 415

DEPARTMENT OF THE NAVY
BUREAU OF SHIPS
WASHINGTON 25, D.C.

S1/4 (415)
SECTION S39-2
8 December 1951

From: Chief, Bureau of Ships.
To: All Holders of General Specifications for Machinery for Vessels of the United States Navy, BuShips Mailing List 451-A.
Insert section in your copy of General Specifications.

M. J. Lawrence,
By direction

GENERAL SPECIFICATIONS FOR MACHINERY FOR VESSELS OF THE UNITED STATES NAVY

DEPARTMENT OF THE NAVY, BUREAU OF SHIPS

SECTION S39-2

THERMAL INSULATION FOR MACHINERY AND PIPING

Superseding section S39-2, dated 1 May 1947.

S39-2-a. Purchase specifications

Issue in effect at date of invitation for bids shall apply.

Copies of Federal (Fed.) specifications, Military (MIL) specifications, Navy Department (N.D.) specifications and Bureau of Ships specifications may be obtained from the Bureau of Supplies and Accounts, or Bureau of Ships, Navy Department, Washington 25, D. C. Naval activities should apply to Commanding Officer, Naval Supply Depot, Scotia 2, N. Y.

S39-2-b. Scope

These specifications cover requirements for insulating and lagging machinery and piping. Where detail specifications herein do not specifically apply to any surface requiring insulation, such surfaces shall be insulated according to the requirements covering a condition which most nearly approximates that of the surface in question.

S39-2-c. Definitions

Insulating material.—Material employed to offer resistance to the flow of heat.

Lagging.—Protective and confining covering or jacket placed over insulating material.

Fastening.—Miscellaneous items with which insulating material is attached to the surface being covered and with which lagging is fixed to insulating material.

Machinery covering and pipe covering.—Composite covering including insulating material, lagging and fastening.

Cold piping.—Piping, the surface temperature of which is below 100° F. except that refrigerant lines designed for refrigeration are defined as "refrigerant piping."

S39-2-d. General design and requirements

Insulate all hot external surfaces of mechanical equipment such as boilers, evaporators, heaters, turbines, boiler feed pumps and feed booster pumps, pipe and tubing, valves and fittings as specified herein. Do not insulate flanged joints in fuel oil piping from fuel oil heaters to and including burner headers. These provisions apply where the temperature of the surface is normally 100° F. or above.

Cold piping and refrigerant piping—Insulate as specified herein. See table 1.

All cold piping located above floor level shall be covered with antisweat insulation which shall be protected against moisture absorption, rotting and disintegration under service conditions. Cold piping below floor level need not be covered except in dry storerooms or other locations where condensed moisture may be undesirable.

Diesel engine exhaust.—All piping, valves, and fittings located in positions exposed to the weather or to salt water spray shall not be insulated but shall be coated on the outside with protective coating, Mil. Spec. MIL-P-15143.

Steam piping.—Insulate all piping, valves and fittings located in positions exposed to the weather or to salt water spray and lag watertight with sheet metal. Where it is not feasible to apply insulation, coat piping with protective coating, Mil. Spec. MIL-P-15143.

Protection of personnel.—In general to be given every consideration by installing suitable guards where hot piping is exposed, removing ragged and serrated edges from sheet metal lagging, and removal of any other hazards which may present themselves.

Pipe anchorages and hangers.—Insulation shall be as complete and efficient as practical. Design shall be such as to reduce heat conducting paths to a minimum. Where temperature of confined fluid exceeds 650° F., thermal insulation shall not be used but pipe hangers shall be designed using low conductivity metals with small areas of contact. Where temperature of confined fluid is 650° F. or less, hangers shall be insulated by low conductivity metals with small areas of contact or by sheet asbestos, asbestos cloth, or other approved material installed between clamp and the piping to a radial thickness not exceeding ⅛ inch. Insulating material around the pipe clamp, particularly in the lower arc, to be adequately supported.

Install insulation so as to insure ready removal and replacement as necessary for service maintenance and repair of the insulated apparatus without destruction or deterioration of such covering. Fastening shall be

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such as to prevent crushing or otherwise reducing the insulating value of the material used.

Finishing cement.—Where these specifications require the use of a layer of finishing cement, any of the following materials, applied and troweled smooth, will be acceptable:

(a) Cement, insulation, asbestos, finishing, N.D. Spec. 32C16.

(b) Cement, insulation, high-temperature, type B, N.D. Spec. 32C14 when used under asbestos lagging.

(c) A mixture of 80 percent cement, insulation, high-temperature, type B (N.D. Spec. 32C14) and 20 percent Portland cement (Fed. Spec. SS–C–192).

Pipe covering shall not be fitted on any piping in voids, cofferdams or tanks, nor shall it cover drain plugs, spectacle flanges or strainer cleanouts.

Air piping.—Insulate where passing through magazines.

Hot water systems.—Insulate completely, including heating tanks, up to the fixtures.

Fire systems.—Insulate completely.

Fresh water systems and flushing systems.—Insulate completely up to the fixtures.

Sprinkling systems, all normally wet piping.—Insulate.

Plumbing and deck drains.—Insulate as necessary to prevent sweating.

Before applying insulation paint machinery and piping in accordance with General Specifications for Building Vessels, Appendix 6.

Insulation shall not be installed on piping connections or joints of any type during pressure tests or until piping has passed satisfactory inspection.

S39-2-e. Detail requirements

The following tables indicate various approved insulating, lagging and fastening materials which shall be used and minimum thicknesses required for all services and temperature ranges.

LIST OF MATERIALS

Materials:	Specification
Cement, adhesive	MIL-C-3316
Cement, insulation, asbestos, finishing	32C16
Cement, insulation, high-temperature	32C14
Cloth, strands, and tape, asbestos	SS-C-466
Cloth, tape and thread; glass, fibrous	32G9
Cork, compressed (corkboard)	HH-C-561
Felt, insulating, asbestos	MIL-F-15091
Insulation, blanket, mineral-wool	32-I-3
Insulation, glass, fibrous; sheets	MIL-I-15475
Insulation, mineral-wool, pipe-covering	32-I-5
Insulation, thermal block	32-I-3
Millboard, asbestos	32M1
Paint, inside, semi-gloss, white, fire-retardant.	JAN-P-703
Paper, sheathing, flameproof and water-repellent.	MIL-P-15006
Pipe covering, cork, molded (with fire resisting compound).	MIL-P-876
Pipe covering, thermal-insulation	MIL-P-2781
Plaster, magnesia	32P10
Protective coating (heat hardening) phenol-formaldehyde.	MIL-P-15143
Steel, sheet, zinc-coated (galvanized)	47B29
Tape, insulating, thermal	MIL-T-15349
Tape, masking	UU-T-106
Wire, copper, soft or annealed	22W9

TABLE 1

Service	Temperature conditions (° F.)	Pipe or tubing		Valves and fittings		Flange joints		Machinery	
		Insulating materials	Lagging	Insulating materials	Lagging	Insulating materials	Lagging	Insulating materials	Lagging
Steam, superheated; gases, exhaust.	751 to 900	MIL-P-2781, grade 3; MIL-T-15349.	SS-C-466, type I, grade A, type IV; 32G9.	32C14, type B MIL-F-15091 type A, 32-I-3, class b, MIL-P-2781, grade 3.	SS-C-466 type I, grade A, B, C, D, type IV 32G9.	MIL-F-15091 type A, 32-I-3, class b; 32P8, grade 3.	SS-C-466 type I, grade C, D.	32C14, type B MIL-F-15091 type A, 32-I-2, 32-I-3, class b.	SS-C-466, type I, grade A, B, C, D, type IV; 32G9.
Steam, superheated; gases, exhaust.	301 to 750	MIL-P-2781 grade 2 & 3 MIL-T-15349.	SS-C-466, type I, grade A, type IV; 32G9.	32C14, type B MIL-F-15091 type A, 32-I-3 class b; MIL-P-2781 grade 2 & 3.	SS-C 466 type I, grade A, B, C, D, type IV; 32G9.	MIL-F-15091 type A, 32-I-3, class b, 32P8, grade 2 & 3.	SS-C-466, type I, grade C, D.	32C14, type B MIL-F-15091 type A, 32-I-2, 32-I-3, class b.	SS-C-466, type I, grade A, B, C, D, type IV; 32G9.
Steam, saturated; gases, exhaust; water, hot; oil, fuel hot.	100 to 300	MIL-P-2781 grade 1, 2; MIL-T-15349.	SS-C-466, type I, grade A, type IV; 32G9; 47B29.	32C14, type B MIL-F-15091 type A, 32-I-3, class a, MIL-P-2781, grade 1 & 2.	SS-C-466, type I, grade A, B, C, type IV; 32G9.	32C14, type B MIL-F-15091 type A, 32-I-3, class a; 22P8, grade 1 & 2.	SS-C-466 type I, grade A, B, C, type IV.	32C14, type B MIL-F-15091 type A, 32-I-2, 32-I-3, class a.	SS-C-466, type I, grade A, B, C, type IV; 32G9.
Water, cold	32 to 99	MIL-F-15091 type A & B; 32-I-5.	SS-C-466, type I, grade A, type IV; 32G9; 89P7.	MIL-F-15091 type A & B; 32-I-5.	SS-C-466 type I, grade A, type IV; 32G9; MIL-P-15008.	MIL-F-15091, type A & B; 32-I-5.	SS-C-466 type I, grade A, type IV; 32G9; MIL-P-15008.	MIL F-15091 type A & B.	SS-C-466 type I, grade A, type IV; 32G9; MIL-P-15008.
Refrigerant (including chilled water).	36 and above.	MIL-P-876 class 1.	SS-C-466 type I, grade A, type IV; 32G9.	MIL-P-876 class 1.	SS-C-466 type I, grade A, type IV; 32G9.	MIL-P-876 class 1.	SS-C-466, type I, grade A, type IV; 32G9.	HH-C-561	SS-C-466, type I, grade A, type IV; 32G9.
Refrigerant	0 to 35	MIL-P-876, class 2.	SS-C-466 type I, grade A, type IV; 32G9.	MIL-P-876, class 2.	SS-C-466 type I, grade A, type IV; 32G9.	MIL-P-876, class 2.	SS-C-466 type I, grade A, type IV; 32G9.	HH-C-561	SS-C-466, type I, grade A, type IV; 32G9.
Refrigerant	Below 0	MIL-P-876 class 3.	SS-C-466 type I, grade A, type IV; 32G9.	MIL-P-876, class 3.	SS-C-466 type I, grade A, type IV; 32G9.	MIL-P-876 class 3.	SS-C-466 type I, grade A, type IV; 32G9.	HH-C-561	SS-C-466, type I, grade A, type IV; 32G9.

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Table 2.—Compounded insulating material thicknesses for hot pipe or tubing

Pipe size (inches)	Temperature range (° F)	Class of material MIL-P-2781		Thickness (inches)		
		Inner layer	Outer layer	Inner layer	Outer layer	Total
½ and ¾	100–388	a, b, or d		⅜		⅜
	389–500	a or		1¾		1¾
		b or d		1½		1½
	501–750	d or		1½		1½
		e		1 15/16		1 15/16
	751–900	e		1 15/16		1 15/16
1	100–388	a or		⅞		⅞
		b or d		1 1/16		1 1/16
	389–500	a or		1¾		1¾
		b or d		1½		1½
	501–750	d or		1½		1½
		e		1 15/16		1 15/16
	751–900	e		1 15/16		1 15/16
1¼		Same materials and thicknesses as ½ inch size				
1½	100–388	a or		⅞		⅞
		b or d		1 1/16		1 1/16
	389–500	a or		1½		1½
		b or d		1⅜		1⅜
	501–750	d or		1⅜		1⅜
		e		1 15/16		1 15/16
	751–900	e		1 15/16		1 15/16
2 and 2½	100–338	a, b, or d		1½		1½
	339–388	a or		2		2
		b or d		1⅞		1⅞
	389–500	a, b, or d		3		3
	501–750	d or		3		3
		e	a or b	1½	1 15/16	3 1/16
	751–900	e	a or b	1½	1 15/16	3 1/16
3	100–338	a, b, or d		1½		1½
	339–388	a or		2		2
		b or d		1⅞		1⅞
	389–500	a, b, or d		3		3
	501–750	d or		3		3
		e	a or b	1½	2	3½
	751–900	e	a or b	1½	2	3½
3½	100–338	a or		1½		1½
		b or d		1¼		1¼
	339–388	a, b, or d		2		2
	389–500	a, b, or d		3		3
	501–750	d or		3		3
		e	a or b	1½	1 15/16	3 1/16
	751–900	e	a or b	1½	1 15/16	3 1/16
4	100–338	a, b, or d		1½		1½
	339–388	a or		2 3/16		2 3/16
		b or d		1⅞		1⅞
	389–500	a, b, or d		3		3
	501–750	d or		3		3
		e	a or b	1½	2	3½
	751–900	e	a or b	1½	2	3½
4½	100–338	a or		1½		1½
		b or d		1¼		1¼
	339–388	a or		2 3/16		2 3/16
		b or d		2		2
	389–500	a, b, or d		3		3
	501–750	d or		3		3
		e	a or b	1½	1 15/16	3 1/16
	751–900	e	a or b	1¼	1 15/16	3 1/16
5		Same materials and thicknesses as 4 inch size				
6		Same materials and thicknesses as 4 inch size				
7	100–338	a, b or d		1½		1½
	339–388	a or		2½		2½
		b or d		2½		2½
	389–500	a, b or d		3		3
	501–750	d or		4		4
		e	a or b	1½	2	3½
	751–900	e	a or b	1½	2	3½
8, 9, and 10	100–338	a, b, or d		1½		1½
	339–388	a or		2½		2½
		b or d		2½		2½
	389–500	a, b or d		3		3

Table 2—Compounded insulating material thicknesses for hot pipe or tubing—Continued

Pipe size (inches)	Temperature range (° F)	Class of material MIL-P-2781		Thickness (inches)		
		Inner layer	Outer layer	Inner layer	Outer layer	Total
8, 9, and 10	501–750	d or		4		4
		e	a or b	2	2	4
	751–900	e	a or b	2	2	4
11	100–338	a, b, or d		1½		1½
	339–500	a, b, or d		3		3
	501–750	d or		4		4
		e	a or b	2	2	4
	751–900	e	a or b	2	2	4
12 and over	100–338	a, b, or d		1½		1½
	339–500	a, b, or d		3		3
	501–750	d or		4		4
		e	a or b	2	2	4
	751–900	e	a or b	2	2	4

Table 3.—Fibrous insulating material thicknesses for hot pipe or tubing

Pipe size (inches)	Temperature range (° F)	Class of material MIL-P-2781		Thickness (inches)		
		Inner layer	Outer layer	Inner layer	Outer layer	Total
½ through 1½	100–388	c		¾		¾
	389–500	c		1½		1½
	501–750	c		2		2
	751–900	f		2		2
2 through 3½	100–338	c		1½		1½
	339–388	c		2		2
	389–500	c		2½		2½
	501–750	c		3		3
	751–850	f	c	1¼	2	3¼
	851–900	f	c	1¼	1½	3¼
4 through 6	100–338	c		1½		1½
	339–388	c		2		2
	389–500	c		2½		2½
	501–750	c		3		3
	751–850	f	c	1½	2	3½
	851–900	f	c	2	1½	3½
7 through 11	100–338	c		1½		1½
	339–388	c		2½		2½
	389–500	c		2½		2½
	501–750	c		4		4
	751–850	f	c	1½	2½	4
	851–900	f	c	2	2	4
12 and over	100–338	c		1½		1½
	339–388	c		2¼		2¼
	389–500	c		2¼		2¼
	501–750	c		4		4
	751–850	f	c	1½	2½	4
	851–900	f	c	2	2	4

Table 4.—Thicknesses of insulating tape, MIL-T-15349 for hot piping ¼ and ⅜ inch in size

Temperature range (°F.)	Thickness of tape (inches)	Number of layers	Total thickness (effective)	Temperature range (° F.)	Thickness of tape inches)	Number of layers	Total thickness (effective)
100–338	¾	1	¾	501–750	½	2	1
339–388	1	1	1	751–900	1 and ¾	1 of each	1
389–500	1¼	1	¾				

Table 5.—Thicknesses* of insulating materials for hot surfaces of machinery

Temperature range (°F.)	Asbestos felt, block or mineral wool blanket	Cement (N. D. Spec. 32C14, type B)	Temperature range (°F.)	Asbestos felt, block or mineral wool blanket	Cement (N. D. Spec. 32C14 type B)
100–338	1½	1½	501–750	3½	4
339–388	2½	2½	751–900	4½	5
389–500	3	3			

*Does not include finishing cement.

Table 6.—Thicknesses of insulating materials in inches for cold and refrigerated surfaces of machinery

Service	Temperature range (° F.)	Corkboard Fed. Spec. HH-C-561	Asbestos felt MIL-F-15091 types A or B	Mineral wool N. D. Spec. 32-I-5
Refrigerant	Below 0	6		
	0 to 35	4		
	36 and over	2		
Cold water	All		1½	1½

Thickness of asbestos felt insulation MIL-F-15091, types A and B, for cold water pipe and tubing, flanges, valves and fittings shall be 1 inch.

Thickness of mineral wool insulation, N. D. Spec. 32-I-5, for cold water pipe and tubing, flanges, valves and fittings shall be 1½ inches.

S39-2-f. Methods of application to pipe or tubing

Hot surfaces.

Each layer of sectional or segmental pipe covering shall be applied with joints tightly butted together and shall be held in place by one of the following methods:

Not less than three separate loops per section of 18 gage (0.049 inch diameter) annealed black or hot dipped galvanized iron wire.

Not less than three galvanized steel bands per section. Bands shall be wrapped with a layer of masking tape (UU-T-106, type II) when glass cloth or tape lagging is to be used.

Where two layers of insulating material are used, apply the second layer over the first so that all joints are staggered.

At flanged joints the molded pipe covering shall be stopped off in such a manner that the flange bolting may be removed easily. This may be done by stopping the pipe covering squarely and inserting a short removable section of molded pipe covering or the insulation may be beveled at an angle of 45 degrees.

For lagging see table 1 and paragraph S39-2-i.

Cold surfaces.

Untreated asbestos felt, water repellent asbestos felt, or low temperature mineral wool pipe covering shall be applied and held in place with 18 gage (0.049 inch diameter) hot dipped galvanized iron wire spirally wound on about 3-inch centers. Cover insulating material with one layer of water repellent and flameproof sheathing paper (MIL-P-15006). Paper shall be tightly wrapped and joints lapped 3 inches each way and sealed completely with adhesive cement (MIL-C-3316, type II).

For lagging see table 1 and paragraph S39-2-i.

Refrigerated surfaces.

Apply sectional cork pipe covering with staggered end joints; longitudinal joints shall be at top and bottom of pipe. At the time of installation coat the molded cork on all surfaces with the fire retardant vapor seal furnished for that purpose. Secure pipe-covering in place with 18 gage (0.049 inch diameter) copper covered steel wire spaced not greater than six loops to a 3-foot section. Wherever pipes pass through a nonwatertight insulated bulkhead into a refrigerated space, insulation shall extend 1 inch inside of refrigerated space. Pipe clamps of hangers shall fit over outside of cork covering and a galvanized sheet steel shield shall be installed between pipe clamp and insulation where piping rests in the hanger.

For lagging see table 1 and paragraph S39-2-i.

S39-2-g. Methods of application to valves, fittings and flanges

Hot surfaces.

Provide readily removable and replaceable covers on the following piping elements requiring insulation:

Flanged joints (except valve bonnet joints) on all sizes of main and auxiliary steam piping carrying steam having a total temperature of 389° F. (205 p. s. i. saturated steam) and over, including flanged joints on all root connections and root valves thereon, such as valve bypasses, drain connections, pressure gage connections, etc.

Flanged joints on piping and adjacent to machinery units which must be broken when these machinery units are opened for inspection and overhaul, such as steam exhaust connections, feed pump suction and discharge connections, steam drain connections, etc.

Valve bonnets on all valves over 2 inches in size, working pressure of 300 p. s. i. and over, carrying fluids 240° F. and over.

Pressure reducing and pressure regulating valves, pump pressure governors, and strainer bonnets.

Readily removable and replaceable covers for piping elements shall be made by one of the following methods:

Covers shall be made in two halves filled with asbestos felt. They shall be sewed and quilted with wire inserted-asbestos yarn (Fed. Spec. SS-C-466, Type II) in such a manner as to provide a uniform thickness. Asbestos cloth, wire inserted (Fed. Spec. SS-C-466, grade C) shall be used on inside of covers. Asbestos cloth (Fed. Spec. SS-C-466, grade B) shall be used on outside surface of cover if the temperature of the insulated surface does not exceed 500° F. For temperatures over 500° F., asbestos cloth (Fed. Spec. SS-C-466, grade D) shall be used on outside of cover. Flexible asbestos millboard, ⅛ inch thick, shall be inserted between the asbestos felt and the asbestos cloth so as to retain cylindrical shape of cover. Hard asbestos millboard, ¼ inch thick, enclosed in asbestos cloth of the type used on the outside of the cover shall be sewn on ends of cover for strength and rigidity. Where the flange diameter is larger than outside diameter of adjacent pipe-covering, build-up pieces shall be made of asbestos felt encased in asbestos cloth (Fed. Spec. SS-C-466, grade D) and secured by stitching to inside of cover. The halves of the cover shall be secured around equipment by 1/16-inch diameter soft galvanized iron rope laced through brass or galvanized steel hooks or rings, or covers shall be secured by snap fasteners made of brass. Fastenings fixed to cloth lagging shall be backed up by washers on both sides of the cloth.

Covers shall be made up of segments of block insulation of the same material used for pipe covering securely wired to frames of ½-inch square mesh of 18 gage (0.049 inch diameter) galvanized steel wire. Wire mesh frames inside and outside of block insulation shall have ends bent over and joints secured with 18 gage black annealed iron wire woven through the mesh. Insulating cement of same material as blocks shall be troweled smoothly over all surfaces of the mesh. Asbestos roll fire-felt (N. D. Spec. 32F1) may be used to build up cover where flange diameter is larger than the outside diameter of the adjacent pipe-covering. Covers shall be lagged with asbestos cloth (Fed. Spec. SS-C-466, grade D) tightly and smoothly fitted to envelop the outside and ends. Where double layer insulation is used the two sections of the cover shall be fitted together with a scarfed joint. Care shall be taken in the workmanship to insure straight and true jointing surfaces of the sections with the view of reducing the heat loss at the joints. Bands and eyelets of galvanized steel or lacing with rings, washers and wire shall be used for securing the cover around the equipment.

Covers shall be made of fibrous sectional pipe-covering (MIL-P-2781, classes c and f) of the same thickness as that on the adjacent piping. Where double layer insulation is used the two sections of the cover shall be fitted together with a scarfed joint. Covers shall be lagged with asbestos cloth (Fed. Spec. SS-C-466, grade D) tightly and smoothly fitted to envelop the outside and ends. Cloth may be cemented with an approved high temperature adhesive cement.

Where the rigid type cover described above is not practicable, for example, because of restricted space, use flexible removable and replaceable covers of the type using asbestos felt, specified in paragraph S39-2-h.

Spaces between inner lagging on removable covers for flanges or other irregular surfaces and such hot metal surfaces shall be filled with pieces of asbestos felt so as to preserve the air cell structure but sufficiently tight to prevent any air circulation.

Permanent insulation for valves, fittings and flanges, shall be made by one of the following methods:

Layers of asbestos felt, MIL-F-15091, type A, shall be applied to a thickness ½-inch less than that of the adjacent pipe covering and secured with 18 gage (0.049 inch diameter) annealed black or hot dipped galvanized iron wire. A ½-inch thick layer of finishing cement shall be laid over the insulating material.

For sizes 3½ inches and under, permanent insulation shall be of insulating cement, N. D. Spec. 32C14, type B, applied to a thickness ½-inch less than that of the adjacent pipe covering. After drying, a ½-inch layer of finishing cement shall be applied.

Insulation shall be of sectional or segmental pipe-covering or block of the same material and thickness as that on the adjacent piping. A ½-inch thick layer of finishing cement shall be laid over the insulating material.

Where practicable, asbestos cloth, Fed. Spec. SS-C-466, grade B, shall be used for lagging if the temperature of the insulated surface is over 500° F. Lagging may be of asbestos cloth or tape, Fed. Spec. SS-C-466, grade A or type IV respectively, or glass cloth or tape (N. D. Spec. 32G9) where the temperature of the insulated surface is 500° F., or less and for temperatures over 500° F. on applications such as butt-welding end fittings where it is desirable to lag the fittings with the material used on the tubing. Asbestos cloth and tape, Fed. Spec. SS-C-466, grade A, and type IV respectively, and glass cloth or tape, N. D. Spec. 32G9 shall not be used where lagging will be in contact with hot metal surfaces.

Cold surfaces.

Removable covers shall not be used. Insulate as specified in paragraph S39-2-f for cold pipe.

Refrigerated surfaces.

Insulate as specified in paragraph S39-2-f for refrigerated pipe.

S39-2-h. Methods of application to machinery and equipment

Hot surfaces.

Machinery and equipment such as boilers, turbines, boiler feed pumps and feed booster pumps, deaerating feed tanks, etc., shall be covered with asbestos felt, MIL-F-15091, type A, block insulating material, N. D. Spec. 32-I-3, mineral wool blanket, N. D. Spec. 32-I-2, or insulating cement N. D. Spec. 32C14, type B. Thicknesses shall be as shown in table 5.

Block, felt and blanket insulating materials shall be securely held in place with hot-dipped galvanized iron wire; 1-inch mesh of 18-gage (0.049 inch diameter) galvanized iron wire shall then be spread over the surface and secured by wiring. Before lagging insulating material, use insulating cement to fill all crevices, smooth all surfaces, and completely coat the wire netting.

Apply insulating cement, N. D. Spec. 32C14, type B, in successive layers of one-half to 1-inch thickness. Allow each layer to dry before applying the next coat and use 1-inch mesh of 18-gage galvanized iron wire between layers.

Lay a coating of finishing cement, ½-inch thick, over the insulating material.

Lagging shall be in accordance with Table 1 and paragraph S39-2-i.

Large flanges such as on turbines shall be insulated with readily removable and replaceable covers made by one of the following methods:

Covers shall be filled with asbestos felt and shall be sewed and quilted with wire inserted asbestos yarn, Fed. Spec. SS-C-466, type II, so as to provide a uniform thickness. Use asbestos cloth, wire inserted, Fed. Spec. SS-C-466, grade C, on inside of covers. Use asbestos cloth, Fed. Spec. SS-C-466, grade B, on outside surface of cover if temperature of insulated surface does not exceed 500° F. For temperatures over 500° F., use asbestos cloth, Fed. Spec. SS-C-466, grade D, on outside of cover.

Make covers in sections formed of insulating block (N. D. Spec. 32-I-3) held together with approved high temperature adhesive cement and covered with ½-inch of finishing cement over which asbestos cloth shall be applied.

Fibrous adhesive cement (MIL-C-15199) may be used with chemically compatible insulating material for fabricating covers.

Removable and replaceable insulation shall fit accurately and shall project over adjacent permanent insulation. Secure removable covers to equipment by ⅛-inch diameter soft galvanized iron rope laced through brass or galvanized steel hooks or rings, or secure covers by brass snap fasteners.

Spaces between inner lagging on removable covers for flanges or other irregular surfaces and such hot metal surfaces shall be filled with pieces of asbestos felt so as to preserve the cell structure but sufficiently tight to prevent any air circulation.

Insulation of manhole covers, handhole covers, drain plugs, and other openings in general as may be required for accessibility shall be readily removable and replaceable without injury.

Insulate uptakes with fibrous glass sheets, MIL-I-15475, or with mineral wool felt, N. D. Spec. 32-I-2. Thickness shall be such as to fill the space described in General Specification, section S52-1.

Clips or hooks or other fastenings for securing insulation are not to be brazed or welded to nonferrous parts of distilling plant equipment.

All main, auxiliary and distilling condensers shall be insulated where the normal operating temperature is 125° F. or more. Where the normal operating temperature is less than 125° F. such equipment shall not be insulated, unless otherwise specified or approved.

Flanges and joints of apparatus operating below atmospheric pressure shall, in general, not be insulated so that inspection for leaks can readily be made.

Cold surfaces.

Insulate as specified in paragraph S39-2-f for cold pipe to a thickness in accordance with table 6.

Refrigerated surfaces.

Insulate as specified in paragraph S39-2-f for refrigerated pipe to a thickness in accordance with table 6.

S39-2-i. Lagging

Provide insulating material with protective lagging conforming to table 1. Fibrous glass lagging shall not be used where subject to abrasion or mechanical injury. Fit lagging smoothly, tape being lapped as required to restrain insulation. Secure asbestos lagging to insulating material and to itself with fibrous insulating adhesive cement (MIL-C-15199) or adhesive cement (MIL-C-3316, type II). Fibrous adhesive cement (MIL-C-15199) shall not be used for securing to metal, nor used with fibrous glass lagging. Secure fibrous glass lagging to insulating materials, itself, and to metal surfaces with adhesive cement (MIL-C-3316, type II). Sodium-silicate shall not be used for securing lagging. Cloth lagging shall be sewed only when adjacent to hot surfaces (such as flanges) where lagging may be exposed to high temperatures.

Use metallic lagging wherever necessary for protection of insulating material from damage. It shall be secured with hardened self-tapping screws using lap joints with a bead on the exposed edge. Cloth or tape lagging is not necessary where metallic lagging is used.

Metallic lagging for piping and applications where the insulation acts as a firm support shall be hot dipped galvanized sheet steel, N. D. Spec. 47629, 0.014 inch nominal thickness. Lagging of not less than 0.025 inch nominal thickness shall be used for other applications.

Fuel oil service piping from fuel oil heaters to and including burner headers shall be lagged with sheet metal.

Paint asbestos and glass cloth or tape lagging with one coat of fire retardant white paint, JAN-T-702, after installation.

U. S. GOVERNMENT PRINTING OFFICE: 1961

Exhibit F

MIL-STD-769(SHIPS)
13 July 1962

MILITARY STANDARD

THERMAL INSULATION REQUIREMENTS FOR MACHINERY AND PIPING

FSC 5640

DEPARTMENT OF THE NAVY

BUREAU OF SHIPS

WASHINGTON 25, D.C.

13 July 1962

Thermal Insulation Requirements for Machinery and Piping
MIL-STD-769(SHIPS)

1. This standard has been approved by the Bureau of Ships, and is published to establish the requirements for thermal insulation for machinery and piping on Naval ships.

2. Use of this standard by activities under the cognizance of the Bureau of Ships shall be mandatory effective on the date of issue.

3. Recommended corrections, additions, or deletions including improvements in the procedures described herein, and changes in this standard which can result in less costly installations without sacrificing the level of quality desired should be addressed to the Chief, Bureau of Ships, Department of the Navy, Washington 25, D.C.

CONTENTS

TABLES

1. SCOPE

1.1 The purpose of this standard is to amplify the general requirements for insulation of piping, machinery, uptakes, and mechanical equipment covered in the General Specifications for Ships of the U.S. Navy or in ships specifications.

2. REFERENCED DOCUMENTS

2.1 The issues of the following documents in effect on the date of invitation for bids form a part of this standard to the extent specified herein:

SPECIFICATIONS

FEDERAL
- T-T-931 - Twine, Cotton, Mattress.
- HH-C-466 - Cloth, Glass (for Membrane Waterproofing and Built-Up Roofing.
- HH-I-525 - Insulation Board, Thermal Cork.
- HH-I-551 - Insulation Block and Pipe Covering (Thermal Cellular Glass).
- QQ-S-775 - Steel, Sheet, Zinc-Coated.
- QQ-W-390 - Wire, Nickel-Chromium-Iron Alloy.
- SS-C-192 - Cement, Portland.
- SS-C-466 - Cloth, Thread, and Tape, Asbestos.
- TT-P-26 - Paint, Interior, White and Tints, Fire-Retardant.
- TT-P-320 - Pigment, Aluminum; Powder and Paste, for Paint.
- UU-T-106 - Tape, Pressure-Sensitive Adhesive, Masking, Paper.

MILITARY
- MIL-P-876 - Pipe-Covering, Cord, Molded (Fire Resistant Vapor-Barrier Coating).
- MIL-I-2781 - Insulation Pipe Covering, Thermal.
- MIL-I-2818 - Insulation Blanket, Thermal, Fibrous Mineral.
- MIL-I-2819 - Insulation Block, Thermal.
- MIL-C-2861 - Cement, Insulation, High-Temperature.
- MIL-C-2908 - Cements, Finishing, Insulation.
- MIL-A-3316 - Adhesives, Fire-Resistant, Thermal Insulation.
- MIL-P-15006 - Paper, Sheathing, Fire-Resistant and Water-Repellent.
- MIL-I-15091 - Insulation Sheet or Strip, Thermal, Asbestos Felt.
- MIL-A-15199 - Adhesive, Asbestos Cloth to Pipe, Insulation.
- MIL-P-15280 - Plastic Foam, Unicellular, Sheet and Tubular Form, Elastomeric.
- MIL-C-15328 - Coating, Pretreatment (Formula No. 117 for Metals).
- MIL-I-15349 - Insulation Tape, Thermal.
- MIL-I-15475 - Insulation Felt, Thermal, Fibrous Glass, Semirigid.
- MIL-I-16411 - Insulation Felt, Thermal, Glass Fiber (for Temperatures Up To 1200 Degrees F.)
- MIL-A-18065 - Adhesives, High Initial Bond.
- MIL-B-19564 - Bedding Compound, Thermal Insulation Pipe Covering.
- MIL-C-19565 - Coating Compound, Thermal Insulation Pipe Covering - Fire-, Water-, and Weather-Resistant.
- MIL-F-20077 - Felt, Asbestos, Roll.
- MIL-C-20079 - Cloth, Glass, Tape, Textile, Glass, and Thread, Glass.
- MIL-I-22023 - Insulation Felt, Thermal and Sound Absorbing Felt, Fibrous Glass, Flexible.
- MIL-I-22344 - Insulation Pipe Covering, Fibrous Glass.

BUREAU OF SHIPS
- General Specifications for Ships of the U.S. Navy.

DRAWINGS

BUREAU OF SHIPS
- 5000-S5103-841336 - Piping, Boiler Soot Blower, Typical Installation.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications.- The following document forms a part of this specification to the extent specified herein. Unless otherwise indicated the issue in effect on date of invitation for bids shall apply.

AMERICAN SOCIETY FOR TESTING MATERIALS
ASTM - A167 - Specification for Corrosion-Resisting Chromium-Nickel Steel Plate, Sheet and Strip.
ASTM - 209 - Specification for Seamless Carbon-Molybdenum Alloy-Steel Boiler and Superheater tubes.

(Application for copies should be addressed to the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Penn.)

3. GENERAL REQUIREMENTS

3.1 General requirements such as definitions, basic applications, and reasons for insulating are covered in the General Specifications for Ships of the U.S. Navy or in ships specifications, Section 9390-2. Thermal insulation and acoustic absorptive treatment of compartments, ventilating ducts and trunks are covered in the appropriate sections of the above specifications.

3.2 Minor deviations in installation which meet the intent of the requirements specified herein may be approved by the cognizant Supervisor of Shipbuilding, U.S. Naval shipyard, or the Bureau of Ships. (A copy of all such changes shall be forwarded to the Bureau of Ships, Code 648L.)

4. MATERIALS AND THICKNESSES

4.1 Minimum thicknesses.- Tables 1 to 10, inclusive specify materials for insulation and lagging and the minimum acceptable thicknesses for the temperature ranges listed.

4.2 Special conditions.- The following special conditions supplement or modify the selection of materials or thicknesses specified, when applicable:

(a) The insulation thickness on soot blower piping between the root valve and the soot blower heads shall be reduced from that indicated for a system normally operating at the same temperature as follows:

(1) Where double layer insulation is used, only the inner (high temperature) insulation thickness layer need be installed.
(2) Where the insulation consists of a single uniform thickness layer, only one-half the total specified thickness need be installed.

(b) The insulation thickness for hot water systems operating at a normal maximum temperature of 150°F. may be 1/2 inch thick for pipe sizes up to 3/4 inch i.p.s., in accordance with MIL-I-2781.
(c) Compounded type insulation in accordance with MIL-I-2781: Where both class b and class e insulations are specified for a double layer insulation, class e, type I may be furnished in a uniform single thickness equal to the total thickness of both layers.
(d) Fibrous type insulation in accordance with MIL-I-2781: Where both class c and class f insulations are specified for a double layer insulation class f may be furnished in a uniform single thickness equal to the total thickness of both layers.
(e) Compounded type insulation conforming to MIL-I-2781, grade I, (calcium silicate only) or cellular glass insulation conforming to HH-I-551 shall be used on hot piping requiring insulation that will be exposed to the weather, and shall conform to the thicknesses shown in table 10.

4.3 Adhesives.- The following adhesives shall be used for fastening cloth and tape lagging:

Type of lagging	Specification
Asbestos	MIL-A-15199[1]/ or MIL-A-3316, type II
Fibrous glass	MIL-A-3316, type I or type II

[1]/Not applicable for cementing to fiber-glass insulation.

4.4 Finishing cements.- Where finishing cement is specified any of the following materials are acceptable subject to any material limitations for the proposed application:

(a) Finishing cement, MIL-C-2908.
(b) High-temperature insulating cement, MIL-C-2861, when used under asbestos cloth.
(c) A mixture of 80 percent high-temperature insulating cement, MIL-C-2861, and 20 percent portland cement, SS-C-192.

4.5 Metal lagging.- Where metal lagging is required, any of the following materials are acceptable, except for uptake applications (see 6.1.4):

Sheet material	Specification	Nominal thickness Inch
Hot-dipped galvanized steel	QQ-S-775	0.014
Aluminum	ASTM 209, Alloy 6061	.030
Corrosion-resistant steel (CRES)	ASTM A167, AISI type 304	.014

5. RE-USABLE COVERS

5.1 Hot-surface insulation covers.- In order to insure that the pipe covering will not interfere with the servicing of a takedown joint where a re-usable cover is installed, the permanent insulation shall stop short of the takedown joint and a short removable and re-usable section of insulation shall be installed between the permanent insulation and the takedown joint. The insulation joint formed by the permanent and re-usable sections may be square, or at an angle of 45 degrees; the joint, however, shall be tight, without any gaps between the two sections and shall incorporate means to prevent dislodging the insulation sections. Re-usable covers are not required on systems insulated with elastomeric foamed plastic insulation (MIL-P-15280).

5.2 Construction.- For sizes larger than 2 inches i.p.s., valve bonnets and valves having takedown joints at the ends shall be fitted with re-usable covers such that the bonnet joint may be removed independently of the valve covering. Valves 2 inches i.p.s. and under shall be fitted with separate covers as indicated above, or covers of a one-piece design such that they may be wrapped around the entire valve body and clipped or otherwise secured just below the handwheel.

5.3 Fabrication, piping components.- For piping components except as otherwise specified, any one of the following methods of fabrication is acceptable:

5.3.1 Covers may be made in two halves of thermal insulating felt enclosed in asbestos cloth. Each half cover shall be sewn and quilted with wire-inserted asbestos yarn conforming to SS-C-466, form II, or fastened with mechanical stapling in a manner to provide a uniform thickness, strength and rigidity.

5.3.2 Covers for use at temperatures of 850°F. and below shall be filled with asbestos felt. Wire-inserted asbestos cloth, SS-C-466, grade AAA-M, shall be used on the inside surface of covers for valves larger than 2 inches i.p.s. For valves 2 inches i.p.s. and smaller, grade AAA shall be used on inside surface of covers. For 500°F. and below, asbestos cloth, SS-C-466, grade AA, shall be used on outside surface of covers; grade AAA cloth shall be used above 500°F.

Table I - Schedule of approved insulation and lagging materials. 1/

Service	Temperature Range (°F.)	Pipe and Tubing		Valves and Fittings		Flange Joints		Machinery	
		Insulation	Lagging	Insulation	Lagging	Insulation	Lagging	Insulation	Lagging
Gases Steam Hot water Oil	125 to 1050	MIL-I-2781 MIL-I-15349 (750°F. Max.) MIL-I-22344 (370 F. Max.) MIL-P-15280 (180°F.Max.)	SS-C-466, grade UG MIL-C-20079	MIL-I-2781 MIL-I-2819 MIL-I-16411 MIL-I-15091, type A MIL-C-2861, MIL-I-22344 (370°F Max.) MIL-P-15280 (180°F Max.)	SS-C-466 MIL-C-20079	MIL-I-2781 MIL-I-2819 MIL-I-16411 MIL-I-15091, type A MIL-C-2861 MIL-I-22344 (370°F. Max.) MIL-P-15280 (180°F. Max.)	SS-C-466 MIL-C-20079	MIL-I-2819 MIL-I-16411 MIL-I-15091, type A MIL-I-2818 MIL-C-2861 MIL-I-22023 (370°F. Max.)	SS-C-466 MIL-C-20079
Cold water	32 to 99	MIL-I-15091 MIL-I-2781 MIL-I-22344 MIL-P-15280	SS-C-466 MIL-C-20079 MIL-P-15006	MIL-I-15091 MIL-I-2781 MIL-I-22344 MIL-I-2819 MIL-P-15280	SS-C-466 MIL-C-20079 MIL-P-15006	MIL-I-15091 MIL-I-2781 MIL-I-22344 MIL-I-2819 MIL-P-15280	SS-C-466 MIL-C-20079 MIL-P-15006	MIL-I-15091 MIL-I-22023 MIL-I-2819	SS-C-466 MIL-C-20079 MIL-P-15006
Refrigerant Chilled water	-20 to 60	HH-I-551 MIL-P-876 MIL-P-15280 (28°F. Min.)	SS-C-466 MIL-C-20079	HH-I-551 MIL-P-876 MIL-P-15280 (28°F. Min.)	SS-C-466 MIL-C-20079	HH-I-551 MIL-P-876 MIL-P-15280 (28°F. Min.)	SS-C-466 MIL-C-20079	HH-I-551 HH-I-525	SS-C-466 MIL-C-20079

1/ Additional materials are covered in 4.5 (metal lagging); 6.1.4 (boiler uptakes); 6.2 (securing antisweat insulation); 6.4.1 (weather deck hot piping)

Table II. - Insulation thicknesses for hot piping, compounded and fibrous conforming to MIL-I-2781.

Pipe size (inches i. p. s.)	Temperature range (degrees F.)	Class[1/]		Nominal thickness (inches)		
		Inner layer	Outer layer	Inner layer	Outer layer	Total
1/2, 1-1/2	125-388	b, c	--	1	--	1
	389-500	b, c	--	2	--	2
	501-750	c, d c or	--	2	--	2
	751-950	e, f f	--	2	--	2
	951-1050	e, f	b, c	2	1-1/2	3-1/2
2 and 2-1/2	125-338	b, c	--	1-1/2	--	1-1/2
	339-388	b, c	--	2	--	2
	389-500	b, c	--	3	--	3
	501-750	c, d c or	--	3	--	3
		c, d f	b, c	1-1/2	1-1/2	3
	751-900	e, f	b, c	1-1/2	1-1/2	3
	901-1050	e, f	b, c	2	1-1/2	3-1/2
3 through 4-1/2	125-338	b, c	--	1-1/2	--	1-1/2
	339-388	b, c	--	2	--	2
	389-500	b, c	--	3	--	3
	501-750	c, d c or	--	3	--	3
		c, d f	b, c	1-1/2	2	3-1/2
	751-900	e, f	b, c	1-1/2	2	3-1/2
	901-950	e, f	b, c	2	1-1/2	3-1/2
	951-1050	e, f	b, c	2-1/2	1-1/2	4
5 and 6	125-338	b, c	--	1-1/2	--	1-1/2
	339-388	b, c	--	2	--	2
	389-500	b, c	--	3	--	3
	501-750	c, d c or	--	3	--	3
		c, d f	b, c	1-1/2	2	3-1/2
	751-900	e, f	b, c	1-1/2	2	3-1/2
	901-950	e, f	b, c	2	1-1/2	3-1/2
	951-1050	e, f	b, c	3	2	5
7	125-338	b, c	--	1-1/2	--	1-1/2
	339-388	b, c	--	2-1/2	--	2-1/2
	389-500	b, c	--	3	--	3
	501-750	c, d c or	--	4	--	4
		c, d f	b, c	1-1/2	2	3-1/2
	751-900	e, f	b, c	1-1/2	2	3-1/2
	901-950	e, f	b, c	2	2	4
	951-1050	e, f	b, c	3	2	5
8 and larger	125-338	b, c	--	1-1/2	--	1-1/2
	339-388	b, c	--	2-1/2	--	2-1/2
	389-500	b, c	--	3	--	3
	501-750	c, d c or	--	4	--	4
		c, d f	b, c	2	2	4
	751-900	e, f	b, c	2	2	4
	901-950	e, f	b, c	2-1/2	2	4-1/2
	951-1050	e, f	b, c	3	2	5

[1/] Where considered desirable, higher temperature classes of insulation of MIL-I-2781 may be used where lower temperature classes are specified (e.g.: where class be is specified, class d or e may be used and where class c is specified, class f may be used) provided they are satisfactory in all other respects.

Table III.- Thickness of insulation conforming to MIL-P-15280 and MIL-I-22344, for hot piping.

Temperature range (°F.)	Specification	Thickness
		Inch
125 to 180	MIL-P-15280 or MIL-I-22344	1/2
181 to 250	MIL-I-22344	1/2
251 to 300	MIL-I-22344	3/4
301 to 370	MIL-I-22344	1

Table IV.- Thickness of insulating tape conforming to MIL-I-15349, for 1/4 to 3/4 inch size hot piping.

Temperature range (°F.)	Pipe size	Thickness
		Inch
125 to 250	1/4, 3/8	3/8
251 to 750	1/4, 3/8	3/8
125 to 250	1/2, 3/4	3/4

Table V.- Thickness 1/ of insulating materials for hot surfaces of machinery and equipment up to 850°F.

Temperature range (°F.)	Thickness (inches)	
	Asbestos felt, MIL-I-15091 MIL-I-2819, or mineral wool blanket MIL-I-2818	Insulating cement, MIL-C-2861
125-338	1-1/2	1-1/2
339-388	2-1/2	2-1/2
389-500	3	3
501-750	3-1/2	4
751-850	4-1/2	5

1/ Does not include finishing cement.

Table VI. - Thickness[1/] of insulating materials for hot surfaces of machinery and equipment over 850°F.

Temperature range (°F.)	Thickness (inches)			
	Felt			Block
	Inner layer MIL-I-16411	Outer layer MIL-I-15091, type A	Total	MIL-I-2819
851-950	2	3	5	4-1/2
951-1050	2	3	5	5

[1/] Does not include finishing cement.

Table VII. - Thickness of refrigerant insulation for piping.

Pipe size (inches)	Temperature range (°F.)	Molded cork, MIL-P-876 Cellular glass, HH-I-551 Nominal[1/] thickness (inches)	
Up to 1-1/4	-20 to -1	2-1/4	1-1/2*
	0 to 40	2	1-1/4*
1-1/2 to 2-1/2	-20 to -1	2-1/2	1-3/4*
	0 to 40	2-1/4	1-1/2*
3 to 5	-20 to -1	3	2*
	0 to 40	2-3/4	1-3/4*

[1/] By nominal thickness is meant a thickness which is approximate and should only be used as a guide in determining actual thickness requirements.
* Thickness for application in air-conditioned spaces only.

Table VIII. - Thickness of refrigerant insulation for machinery and equipment (exclusive of vapor barrier).

Temperature range (°F.)	Thickness (inches)			
	Corkboard, HH-I-525		Cellular glass, HH-I-551	
0 to 35	4	1*	5	1-1/2*

*Thickness for application in air-conditioned spaces only.

Table IX. - Thickness of antisweat insulation (exclusive of vapor barrier).

Temperature range (°F.)	Machinery and equipment			Piping		
	Material specification	Thickness (inches)		Material specification	Thickness (inches)	
28 to 99	MIL-I-15091 MIL-I-2819	1-1/2	3/4*	MIL-I-15091 MIL-I-2781 MIL-I-2819	1	1/2*
	MIL-I-22023	1	1/2*	MIL-P-15280 MIL-I-22344	3/4	1/2*

*Thickness for application in air conditioned spaces only.

Table X. - Nominal thicknesses of insulation for weather deck hot piping.

Pipe size (inches i.p.s.)	Calcium silicate, MIL-I-2781 Cellular glass, HH-I-551
	Inches
1/4 to 3	1-1/2
3-1/2 to 6	2
Over 6	2-1/2

5.3.3 Covers for use at temperatures above 850°F. shall have filling consisting of inner layers of fiber-glass felt, MIL-I-16411, outer layers of asbestos felt, and shall be covered on the inside surface and on the ends with nickel-chromium alloy wire mesh, QQ-W-390 (or wire-inserted asbestos cloth, SS-C-466, grade AAA-M, for services up to 950°F.) and on the outside surface with grade AAA asbestos cloth. Asbestos roll felt, MIL-F-20077 1/8 inch thick, shall be inserted between the asbestos felt and the asbestos cloth to retain the cylindrical shape of the cover.

5.3.4 Hard asbestos millboard, 1/4 inch thick, enclosed in asbestos cloth of the type used on the outside cover, shall be sewn on ends of covers for strength and rigidity. When a more flexible cover is necessary, such as when space limitation would not permit installation of the more rigid type, the millboard will not be required. When the flange diameter is larger than the outside diameter of the adjacent pipe covering, build-up pieces made of asbestos felt encased in asbestos cloth, SS-C-466, grade AAA shall be stitched to inside of cover. Halves of covers shall be fastened together by 1/16-inch diameter galvanized, or other corrosion resistant, wire rope laced through brass or galvanized steel hooks or rings, or fastened by brass snap fasteners. Fastenings shall be securely attached to cloth lagging.

5.3.5 Covers may be made of segments of block insulation or molded pipe insulation, having the same thickness as that on the adjacent piping. Blocks shall be securely wired to frames of 1/2 inch square mesh, Number 18 gage (0.049-inch diameter) galvanized steel wire. Wire mesh frames inside and outside of blocks shall have ends bent over and joints secured with Number 18 gage black annealed iron wire woven through the mesh. Insulating cement of the same material as the blocks shall be troweled smoothly over all surfaces of the wire mesh. Asbestos roll felt may be used to build up covers when the flange diameter is larger than the outside diameter of the adjacent pipe covering. Covers shall be tightly and smoothly lagged to envelop the outside and ends. For temperatures of 500°F. and below asbestos cloth lagging conforming to SS-C-466, grade AA, shall be used; grade AAA cloth shall be used above 500°F. Lagging may be

cemented or sewn on, except ends of covers shall always be sewn. Where double layer insulation is used the two sections of the cover shall be fitted together with a scarfed joint. Such joints shall be straight and true to reduce heat loss. Bands, eyelets, or locks of galvanized steel, or lacing with hooks, rings, washers, and wire shall be used to secure the covers.

5.3.6 When installing the above covers, spaces between inner surfaces of covers for flanges and other irregular surfaces shall be filled with pieces of asbestos felt when temperatures are 850°F. or less. Fiber-glass felt in accordance with MIL-I-16411, shall be used similarly above 850°F. Felt shall be packed loose enough to preserve air cell structure and tight enough to prevent air circulation.

5.4 Fabrication, machinery and equipment. - For re-usable covers for machinery and equipment, either of the following methods of fabrication is acceptable.

5.4.1 Covers may be similar to the flexible asbestos felt or fiber-glass felt type described for piping components.

5.4.2 Covers may be made in sections formed of insulating block held together with wire and adhesive cement, covered with 1/2-inch thickness of finishing cement, and lagged. Lacing with hooks, rings, washers, and wire, or brass snap fasteners shall be used to secure the covers.

6. INSTALLATION

6.1 Hot surface insulation. -

6.1.1 Pipe and tubing. - Each layer of molded insulation shall be installed with joints butted together. Where two layers are used all joints shall be staggered. Not less than three fastenings shall be used for securing each 3-foot section of insulation. Fastening shall be Number 18 gage (0.049-inch diameter) annealed black or hot-dipped galvanized iron wire or flat steel bands. Except as otherwise specified, lagging shall be installed over the insulation.

6.1.1.1 The installation of soot blower piping insulation shall be in accordance with drawing 5000-S5103-841336.

6.1.2 Piping components. - For valves, fittings, and accessories, welded and brazed fittings including unions may be insulated and lagged similarly to adjacent piping.

6.1.2.1 Block, felt, blanket insulating materials, or molded pipe insulation secured with hot-dipped galvanized iron wire, may be used. When insulating felts are used above 850°F. the inner layer shall be fiber-glass felt conforming to MIL-I-16411. Galvanized iron wire netting, Number 18 gage (0.049-inch diameter), shall be spread over the insulating material and secured with wire. Insulating cement shall be used to fill all crevices, smooth all surfaces, and completely cover the wire netting. A 1/2-inch thickness of finishing cement shall then be applied. Insulating material shall be the same thickness as that on adjacent piping.

6.1.2.2 For components 3-1/2 inch i.p.s. and smaller, insulating cement only conforming to MIL-C-2861, may be applied to a thickness 1/2 inch less than the adjacent pipe insulation. A 1/2 inch thickness of finishing cement shall be applied over the insulating cement.

6.1.2.3 Re-usable covers shall be fitted where required.

6.1.3 Machinery and equipment. - For machinery and equipment, block, felt, or blanket insulating materials of the required thickness shall be secured with hot-dipped galvanized iron wire. Galvanized iron wire netting 1-inch mesh and Number 18 gage (0.049-inch diameter) shall be spread over the surface and secured by wire. Insulating cement shall be used to fill all crevices, smooth all surfaces, and completely cover the wire netting.

6.1.3.1 When no insulating cement has been specified, a 1/2-inch thickness of finishing cement shall be applied.

6.1.3.2 When an insulating cement has been specified it shall be applied in successive layers, 1/2 inch to 1 inch in thickness, until the total thickness specified has been reached. Wire netting, similar to that used for covering the insulating materials, shall be installed between layers. A 1/2-inch thickness of finishing cement shall be applied over the last layer of insulating cement.

6.1.3.3 Lagging shall be installed over finishing cements. Re-usable covers shall be installed where required.

6.1.3.4 Clips, hooks, or other fastenings for securing insulation or lagging shall not be brazed or welded to nonferrous parts of distilling plants or deaerating feed tanks.

6.1.4 Boiler uptakes. - For boiler uptakes the thermal insulation shall be 2 inches thick. Either mineral wool felt, MIL-I-2818, or fibrous glass sheet, MIL-I-15475, may be used. If acoustic absorptive treatment is found to be necessary to decrease the noise level the insulation thickness shall be increased accordingly.

6.1.4.1 Metal lagging for uptakes shall be galvanized sheet steel conforming to QQ-S-775, not less than 1/32 inch thick.

6.1.4.2 Insulation and lagging is not required on uptakes above the weather deck.

6.2 Antisweat insulation.

6.2.1 Molded pipe covering, untreated asbestos felt, water repellent asbestos felt, or fibrous glass blanket insulation shall be secured with Number 18 gage (0.049-inch diameter) hot-dipped galvanized iron wire, wire inserted asbestos yarn, or glass thread, MIL-C-20079, spirally wound on 1-inch centers. One layer of water repellent and flameproof sheathing paper, MIL-P-15006, shall be wrapped tightly around the insulation and secured with cotton twine, T-T-931, or 1-inch wide tape, UU-T-106. All joints of the paper shall be lapped and sealed with adhesive cement, MIL-A-3316, type II. The compatible lagging shall then be installed and completely covered with vapor barrier compound, MIL-P-876.

6.2.2 Application of a vapor barrier is not required on elastomeric foamed plastic insulation, MIL-P-15280, nor is lagging required except in areas where such insulation would be subject to damage.

6.3 Refrigerant insulation.

6.3.1 Molded cork insulation shall be coated on all surfaces with vapor barrier compound, MIL-P-876, at the time of installation. Insulation shall be installed with staggered end joints. On horizontal pipes the longitudinal joints shall be at the top and bottom. Insulation shall be secured with Number 18 gage (0.049-inch diameter) copper-covered steel wire spaced not greater than six loops to a 3-foot section. Molded cellular glass insulation shall be similarly coated and installed, except that fastenings shall be on 9-inch centers; 1-inch wide tape, UU-T-106, may be used instead of wire. The compatible lagging shall then be installed.

6.4 Weather deck hot piping insulation.

6.4.1 Calcium silicate or cellular glass insulation for piping exposed to the weather shall be installed as follows:

(a) Preliminary preparation of piping.

(1) All surfaces to be clean, dry, and free of scale and grease.
(2) Fittings, valves, flanges, pipe supporting clamp, and at least 3 inches of adjacent pipe shall be painted as follows: Apply one coat pretreatment formula 117, MIL-C-15328. After this coat dries, apply two coats of aluminum paint made by mixing two pounds of aluminum paste, TT-P-320, type II, class B, with each gallon of phenolic varnish.

(b) Installation on pipes

(1) The bore, butt ends, and longitudinal joint surfaces of the insulating material shall be coated not more than 1/16 inch thick with commercial bedding compound, in accordance with MIL-B-19564, at time of installation.

(2) Longitudinal joints on horizontal piping shall be on top and bottom of pipe.
(3) Insulation shall be secured tightly to pipe with 1/2-inch wide U.S. Standard 22 gage galvanized steel bands on 9-inch centers. Steel bands shall be placed over a layer of fibrous glass tape, MIL-C-20079, class c, which has been dipped in the commercial finishing compound in accordance with MIL-C-19565. Steel bands shall be wrapped with a layer of masking tape, UU-T-106, type II.
(4) Completely coat insulation with commercial finishing compound, in accordance with MIL-C-19565, using about 2 gallons per 100 square feet. Wrap on tightly one layer of open weave fibrous glass cloth, HH-C-466, or knitted fibrous glass tape, MIL-C-20079, and then apply another coating of above-specified finishing compound, using about 4 gallons per 100 square feet. After this coat has set apply a second coat of finishing compound using the same quantities.
(5) Where insulation is stopped off on the piping, sufficient mineral wool, MIL-I-2818, shall be tightly tied in place with galvanized iron wire over a heavy coating of the above-specified commercial bedding compound, to provide a tapered portion from insulation surface to pipe surface. Lag and coat with same method and materials as adjacent piping.

(c) Installation on fittings, flanges, and valves.

(1) Before applying flange insulation weather deck piping shall be tested and secured in the following manner: After specified tests are completed, weather deck piping shall be subjected to alternate periods of full operating pressure, allowing pipe to come to maximum temperature; and then to zero gage pressure allowing pipe to cool to ambient temperature. These cycles shall be repeated a sufficient number of times, tightening and adjusting flanges where necessary until no leaks can be detected.
(2) Fittings, flanges, and valve covers shall be ship-fabricated from sections of molded pipe covering or cellular glass block cemented together with adhesive cement, MIL-A-18065, class 1.
(3) Permanent covers for fittings and valves shall be fitted snugly to fittings and adjacent pipe covering using the same materials and methods as outlined for pipe covering. Voids between insulation and fitting shall be filled with tightly packed mineral wool, MIL-I-2818.
(4) Where specified, rigid-type portable flange covers shall extend over the adjacent pipe covering 1-1/2 times the thickness of the insulation. The two halves of the cover should be coated and lagged separately, using the same materials and procedure as outlined for pipe covering. The galvanized steel bands used to secure the two halves together and to the adjacent pipe covering shall be applied over the lagging and then coated with the above-specified finishing compound.

(d) Installation around supports and hangers.

(1) Remove only enough insulation from butt edges to provide a snug fit around support brackets or hanger rods. Fill all voids between insulation and support with tightly packed mineral wool, MIL-I-2818, to within 1/4 inch from insulation surface. Fill remainder of the space with the above-specified finishing compound overlapping generously both the support member and the adjacent insulation.

6.5 Metal lagging.- Metal lagging shall be installed with lap joints, secured with hardened self-tapping screws or metal bands.

6.6 Painting.- All cloth and tape laggings shall be painted after installation with one coat of fire-retardant white paint, TT-P-26, if necessary for appearance. Elastomeric foamed plastic insulation MIL-P-15280 shall not be painted except where necessary for appearance. (For material and application requirements, see Section 9190-1 of the General Specifications for Ships of the U.S. Navy or ships specifications.)

7. NOTES

Notice.- When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be

regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

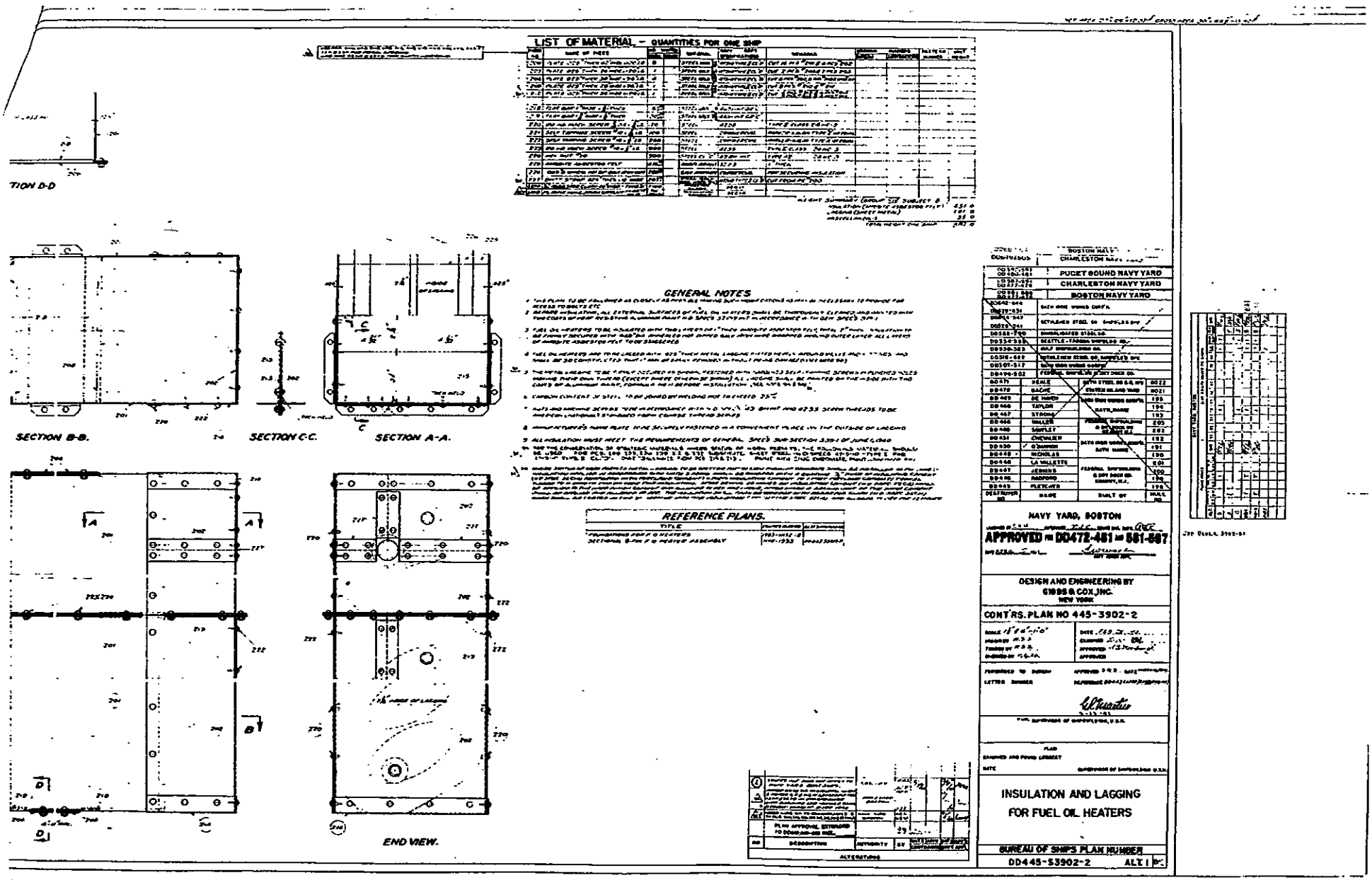
(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring agency or as directed by the contracting officer.)

(Copies of this standard for military use may be obtained as indicated in the foreword to, or the general provisions of, the Index of Military Specifications and Standards.)

Both the title and the identifying number should be stipulated when requesting copies of Military Standards.

Preparing activity:
Navy - Ships
(Project 5640-N023Sh)

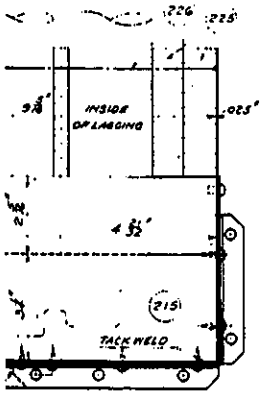
Exhibit G



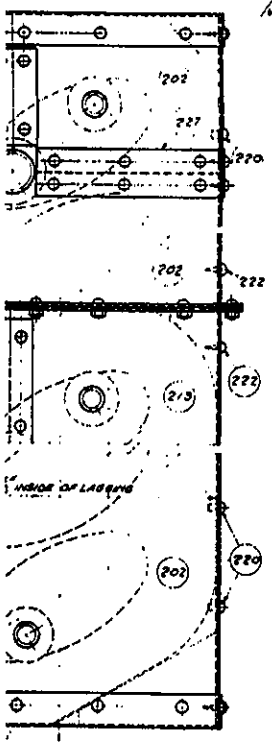
PIECE NO	NAME OF PIECE	NO WANTED ON BILL	NO WANTED ON BOARD	MATERIAL	NAVY DEPT SPECIFICATIONS	REMARKS	DRAWING BUREAU	NUMBER & CONTRACTOR	NUMBER
200	PLATE .025" THICK 42" WIDE x 120" LG	8		STEEL GALV	4131 OTYPE II CL "D"	CUT 16 PCS. @ 201 & 4 PCS. @ 202			
203	PLATE .025" THICK 24" WIDE x 120" LG.	1	"	STEEL GALV.	4131 OTYPE II CL "D"	CUT 2 PCS. @ 204 & 2 PCS. 205			
206	PLATE .025" THICK 30" WIDE x 96" LG.	4		STEEL GALV.	4131 OTYPE II CL "D"	CUT 8 PCS. @ 207, & 4 PCS. @ 208 & 8 PCS. @ 209			
209	PLATE .025" THICK 28" WIDE x 96" LG.	1		STEEL GALV.	4131 OTYPE II CL "D"	CUT 8 PCS. @ 210 & @ 211.			
212	PLATE .025" THICK 36" WIDE x 120" LG.	1		STEEL GALV.	4131 OTYPE II CL "D"	CUT 1 PC. @ 213, 1 PC. @ 214, 1 PC. @ 215, 1 PC. @ 216, 1 PC. @ 217 & 1 PC. @ 218			
218	FLAT BAR 1" WIDE x 1/8" THICK	6 LGTH		STEEL GALV.	4631 INT GR "C"				
219	FLAT BAR 1" WIDE x 1/8" THICK	30 LGTH		STEEL GALV.	4631 INT GR "C"				
220	RD HD. MACH. SCREW 1/4" DIA x 1/2" LG.	120		STEEL	4235	TYPE II CLASS 2A NC-3			
221	SELF TAPPING SCREW #10 x 1/2" LG.	100		STEEL	COMMERCIAL	PARKER-KALON TYPE A OR EQUAL			
222	SELF TAPPING SCREW #10 x 1" LG.	260		STEEL	COMMERCIAL	PARKER-KALON TYPE A OR EQUAL			
223	RD. HD MACH SCREW #10 x 1/2" LG.	900		STEEL	4235	TYPE II CLASS 2A NC 3			
224	HEX. NUT #10	900		STEEL CL "C"	4311 INT	TYPE A2 2A NC 3			
225	AMOSITE ASBESTOS FELT	475 SQ FT		AMOSITE AND FELT	37 F3	1" THICK.			
226	.049" D ANNEAL HOT DIP GALV IRON WIRE	280 FT		GALV IRON WIRE	COMMERCIAL	FOR SECURING INSULATION			
227	BUTT STRAP .025" THICK x 1" WIDE	20 FT		STEEL GALV.	4130 TYPE II CL "D"	CUT FROM PC. 200			
227A	ASBESTOS CLOTH 60" WIDE - TYPE "A"	7 YDS		FABRIC INSULATING CEMENT	51 G 11				
227B	PLASTIC INSUL. ASBESTOS CEMENT TYPE "A"	40 LBS			51 G 14				

WEIGHT SUMMARY (GROUP XIV SUBJECT 8)

INSULATION (AMOSITE ASBESTOS FELT)	451.0
LAGGING (SHEET METAL)	101.0
MISCELLANEOUS	35.0
TOTAL WEIGHT ONE SHIP	587.0



SECTION A-A.



END VIEW.

GENERAL NOTES

1. THIS PLAN TO BE FOLLOWED AS CLOSELY AS POSSIBLE MAKING SUCH MODIFICATIONS AS MAY BE NECESSARY TO PROVIDE FOR ACCESS TO BOLTS ETC
2. BEFORE INSULATING, ALL EXTERNAL SURFACES OF FUEL OIL HEATERS SHALL BE THOROUGHLY CLEANED AND PAINTED WITH TWO COATS OF HEAT RESISTING ALUMINUM PAINT N.O. SPEC'S 32 P 19 INT IN ACCORDANCE WITH GEN SPEC'S 319-1
3. FUEL OIL HEATERS TO BE INSULATED WITH TWO LAYERS OF 1" THICK AMOSITE ASBESTOS FELT, TOTAL 2" THICK. INSULATION TO BE FIRMLY SECURED WITH .049" DIA. ANNEALED HOT DIPPED GALV IRON WIRE WRAPPED AROUND OUTER LAYER. ALL LAYERS OF AMOSITE ASBESTOS FELT TO BE STAGGERED.
4. FUEL OIL HEATERS ARE TO BE LAGGED WITH .025" THICK METAL LAGGING FITTED NEATLY AROUND VALVES AND FITTINGS AND SHALL BE SO CONSTRUCTED THAT IT MAY BE EASILY REMOVED WITHOUT BEING DAMAGED. (SEE NOTE 9B)
5. THE METAL LAGGING TO BE FIRMLY SECURED AS SHOWN, FASTENED WITH HARDENED SELF-TAPPING SCREWS IN PUNCHED HOLES MAKING THEIR OWN THREAD (EXCEPT WHERE OTHERWISE SHOWN) ALL LAGGING SHALL BE PAINTED ON THE INSIDE WITH TWO COATS OF ALUMINUM PAINT, FORMULA NO 11 BEFORE INSTALLATION. (SEE NOTE 9A & 9B)
6. CARBON CONTENT OF STEEL TO BE JOINED BY WELDING NOT TO EXCEED .25%
7. NUTS AND MACHINE SCREWS TO BE IN ACCORDANCE WITH N.O. SPEC'S 43-B11 INT AND 42 35 SCREW THREADS TO BE AMERICAN (NATIONAL) STANDARD FORM COARSE THREAD SERIES.
8. MANUFACTURER'S NAME PLATE TO BE SECURELY FASTENED IN A CONVENIENT PLACE ON THE OUTSIDE OF LAGGING
9. ALL INSULATION MUST MEET THE REQUIREMENTS OF GENERAL SPEC'S SUB-SECTION 339-1 OF JUNE 1, 1940.

9A. FOR THE CONSERVATION OF STRATEGIC MATERIALS WHERE STATUS OF WORK PERMITS, THE FOLLOWING MATERIALS SHOULD BE USED: FOR PCS. 100, 203, 206, 209, 212 & 227 SUBSTITUTE SHEET STEEL IN N.O. SPECS. 47-5-110 - TYPE I FOR (47-5-110 TYPE II CL "D". OMIT "GALVANIZE" FROM PCS. 218 & 219. PAINT WITH ZINC CHROMATE PAINT. (SEE NAVSHIPS 911)

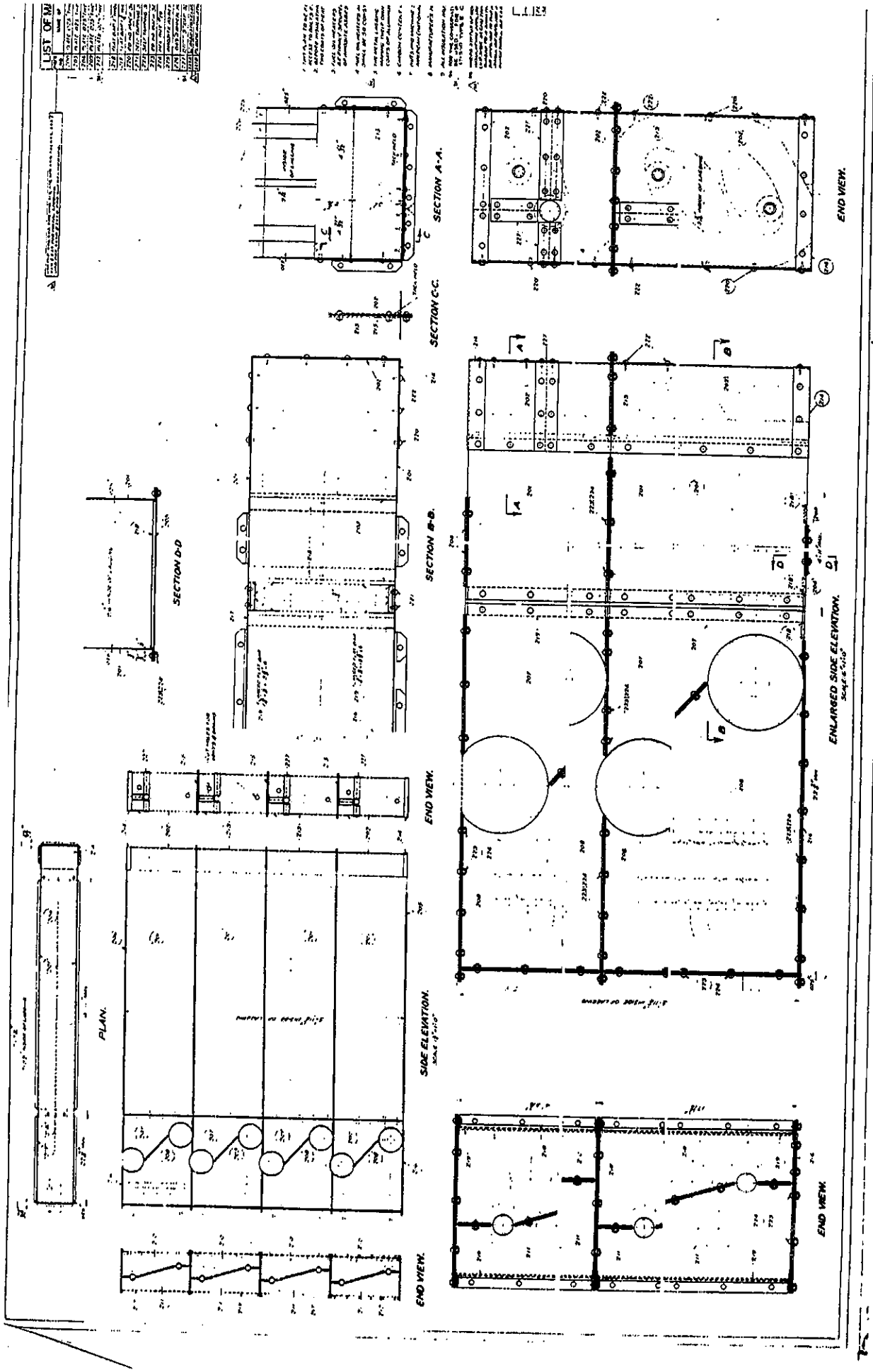
9B. WHERE STATUS OF WORK PERMITS METAL LAGGING TO BE OMITTED WITH LIKE THICKNESS OF CORDING SHALL BE INSTALLED AS TO LEAVE 1" INSULATION APPLIED IN ACCORDANCE WITH NOTE 3 ABOVE. SHALL BE COVERED WITH A COATING OF "ARMOR MASTIC CEMENT" (NO SPEC. SECIA) THOROUGHLY WITH PORTLAND CEMENT (A PART) INSULATION CEMENT) TO 1 PART PORTLAND CEMENT) FORMED SURFACE TO A SMOOTH FINISH OVER THIS INSULATION. AFTER DRYING 48 HOURS ANY INSULATION CEMENT (N.O. SPEC. 51 G 8) SHALL BE APPLIED IN TWO HOUR PERIODS CONSTANT AND ALLOWED TO DRY FOR 7 HOURS, AFTER WHICH IT SHOULD BE SMOOTH AND SHALL BE APPLIED FOR ALLOWED TO DRY. THIS INSULATION SHALL FINISH AS OUTSIDE WITH ASBESTOS CLOTH (N.O. SPEC. 51 G 11) WHICH SHALL BE COATED ON THE OUTSIDE WITH THIS INSULATION FOR "SURFACE" SPEC. 51 G 14) AND ALLOWED TO DRY FOR 72 HOURS.

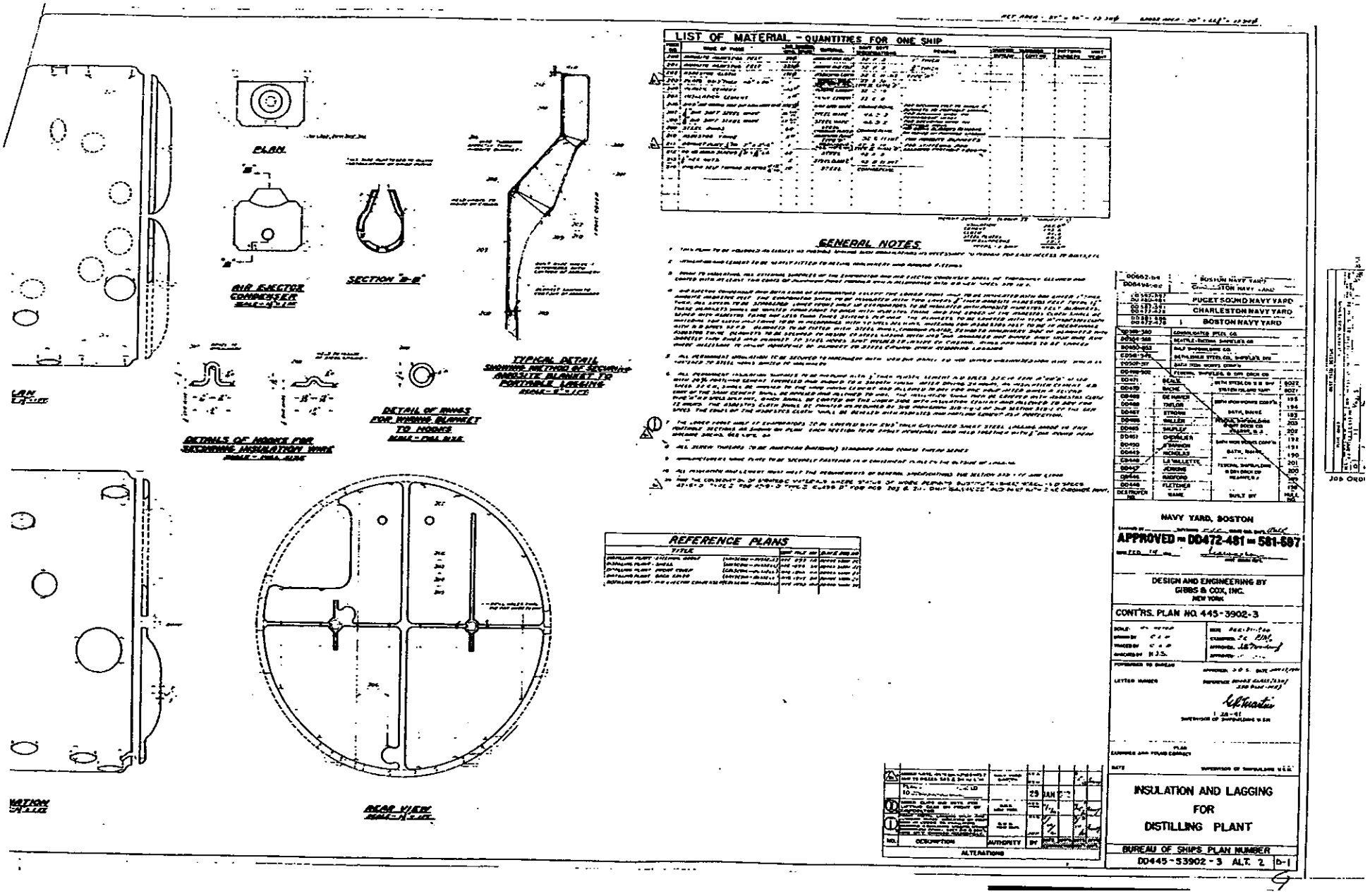
REFERENCE PLANS.

TITLE	CONTR'S PLAN NO	BU OF SHIPS PLAN NO
FOUNDATIONS FOR F.O. HEATERS.	1983-111132-18	
SECTIONAL U-PIN F.O. HEATER ASSEMBLY	NYE-1933	100443-331631

NO	DESCRIPTION	AUTHORITY	BY	DATE APPD CONTRACTOR	DATE APPD GOV'T. APPL.
1	CONTR'S ALT. DOES NOT APPLY TO NAVY YARD BOAT SHOP.	NAVY YARD BOSTON			
2	ADDED NOTE 9A TO REMARKS COL. & TO PCS. 100, 203, 206, 209, 212 & 227 INCL.	NAVY YARD BOSTON			
	PLAN APPROVAL EXTENDED TO DD 648, 662-666 INCL.		29 JAN		

ALTERATIONS


LIST OF MA
SECTION A-A.
SECTION C-C.
END VIEW.
SECTION B-B.
SECTION D-D
ENLARGED SIDE ELEVATION.
END VIEW.
PLAN.
SIDE ELEVATION.
END VIEW.
END VIEW.



NET AREA = 27" x 66" = 12.38 ☐'

LIST OF MATERIAL - QUANTITIES FOR ONE SHIP

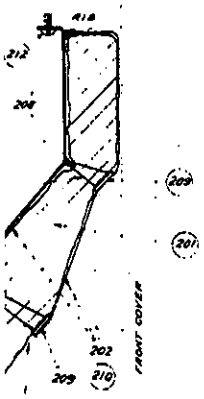
PIECE NO.	NAME OF PIECE	NO. WANTED ORIG.	SPARE	MATERIAL	NAVY DEPT SPECIFICATIONS	REMARKS	DRAWING NUMBERS BUREAU	DRAWING NUMBERS CONT. NO.	PATTERN NUMBERS	UNIT WEIGHT
200	AMOSITE ASBESTOS FELT	504		AMOSITE ASB FELT	32 F 3	1" THICK				
201	AMOSITE ASBESTOS FELT	2256		AMOSITE ASB FELT	32 F 3	½" THICK				
202	ASBESTOS CLOTH	1158		ASBESTOS CLOTH	32 C 11 INT.	TYPE "A"				
203	PLATE - .0313" THICK 48" x 96"	1		GALVANIZED SHEET STEEL	47-8-10 TYPE II CLASS "D"					
204	PLASTIC CEMENT	145 ☐'		PLASTIC CEMENT	32 C 14					
205	INSULATION CEMENT	5 ☐'		INSULATION CEMENT	32 C 8					
206	.049" DIA ANNEALED NOT DIPPED GALVANIZED IRON WIRE	252 LB		SOFT IRON WIRE	COMMERCIAL	FOR SECURING FELT TO BRACE & ANGLES TO PIPE COVERING AND SECURING WIRE ON HANGERS AT 24" C.				
207	¼" DIA SOFT STEEL WIRE	16 LB		STEEL WIRE	46 A 2	FOR SECURING WIRE ON PIPE COVERING				
208	¼" DIA SOFT STEEL WIRE	17 LB		STEEL WIRE	46 A 2	FOR SECURING WIRE ON PIPE COVERING				
209	STEEL RINGS	60		CADMIUM PLATED STEEL	COMMERCIAL	FOR SECURING BLANKETS TO HOOKS ON INSIDE OF CASING, LOOSE				
210	ASBESTOS TWINE	2 ☐'		ASBESTOS TWINE TYPE "D"	32 C 11 INT.	FOR AMOSITE BLANKETS				
211	BRACKET PLATE ¼" THK 3" x 3" x 4"	1		STEEL PLATE (OR SECTION)	42 A 10 TYPE II GRADE "B"	FOR SUPPORTING HOOKS AND SECURING PORTABLE LAGGING				
212	#8-32 MACH SCREWS ½" x ¼" LG	60		STEEL	42 A 5					
213	¼" HEX NUTS	12		STEEL CLASS C	43 B 11 INT					
214	NALON SELF-TAPPING SCREWS #12 x ¾" LG	10		STEEL	COMMERCIAL					

WEIGHT SUMMARY (GROUP XX - SUBJECT 1)

INSULATION	207.6 ☐'
CEMENT	193.6
CLOTH	41.6
STEEL PLATES	44.5
MISCELLANEOUS	13.1
TOTAL - 1 SHIP	990.6 ☐'

GENERAL NOTES

1. THIS PLAN TO BE FOLLOWED AS CLOSELY AS POSSIBLE MAKING SUCH MODIFICATIONS AS NECESSARY TO PROVIDE FOR EASY ACCESS TO BOLTS, ETC.
2. INSULATION AND CEMENT TO BE NEATLY FITTED TO ACTUAL MACHINERY AND AROUND FITTINGS.
3. PRIOR TO INSULATING, ALL EXTERNAL SURFACES OF THE EVAPORATOR AND AIR EJECTOR CONDENSER SHALL BE THOROUGHLY CLEANED AND COATED WITH AT LEAST TWO COATS OF ALUMINUM PAINT FORMULA A911 IN ACCORDANCE WITH N.D. GEN. SPECS. 319.16-1.
4. AIR EJECTOR CONDENSER AND BOTH ENDS OF EVAPORATORS EXCEPT THE LOWER FRONT HALF TO BE INSULATED WITH ONE LAYER 1" THICK AMOSITE ASBESTOS FELT. THE EVAPORATOR SHELL TO BE INSULATED WITH TWO LAYERS ½" THICK AMOSITE ASBESTOS FELT TOTAL 1" THICK. ALL LAYERS TO BE STAGGERED. LOWER FRONT HALF OF EVAPORATORS TO BE INSULATED WITH AMOSITE ASBESTOS FELT BLANKETS. THESE BLANKETS SHALL BE QUILTED FROM FRONT TO BACK WITH ASBESTOS TWINE AND THE EDGES OF THE ASBESTOS CLOTH SHALL BE SEWED WITH ASBESTOS TWINE NOT LESS THAN THREE STITCHES PER INCH. THE BLANKETS TO BE COVERED WITH TYPE "A" ASBESTOS CLOTH. MATERIAL FOR CLOTH AND TWINE TO BE IN ACCORDANCE WITH N.D. SPECS. 32 C 11 INT. MATERIAL FOR ASBESTOS FELT TO BE IN ACCORDANCE WITH N.D. SPECS. 32 F 3. BLANKETS TO BE FITTED WITH STEEL RINGS, CADMIUM PLATED, SEWED TO MACHINERY SIDE OF BLANKETS WITH ASBESTOS TWINE. BLANKETS TO BE SECURED TO INSIDE OF STEEL CASING WITH .049" DIA. ANNEALED NOT DIPPED GALV. IRON WIRE RUN DIRECTLY THRU RINGS AND BLANKET TO STEEL HOOKS SPOT WELDED TO INSIDE OF CASING. RINGS AND HOOKS TO BE SPACED WHERE NECESSARY TO INSURE ADHERENCE OF BLANKET TO STEEL CASING WHEN REMOVING LAGGING.
5. ALL PERMANENT INSULATION TO BE SECURED TO MACHINERY WITH .049 DIA ANNEALED NOT DIPPED GALVANIZED IRON WIRE, WHICH IS FASTENED TO STEEL HOOKS SPOT WELDED TO MACHINERY.
6. ALL PERMANENT INSULATION SURFACES TO BE AVERLAID WITH ½" THICK PLASTIC CEMENT N.D. SPECS. 32 C 14 TYPE "A" OR "B" MIXED WITH 20% PORTLAND CEMENT, TROWELED AND RUBBED TO A SMOOTH FINISH. AFTER DRYING 24 HOURS, AN INSULATION CEMENT N.D. SPECS. 32 C 8, SHALL BE APPLIED TO THE HARD FINISH CEMENT AND ALLOWED TO DRY FOR ONE HOUR, AFTER WHICH A SECOND COAT OF THE SAME CEMENT SHALL BE APPLIED AND ALLOWED TO DRY. THE INSULATION SHALL THEN BE COVERED WITH ASBESTOS CLOTH TYPE "A" N.D. SPECS 32 C 11 INT., WHICH SHALL BE COATED ON THE UNDER SIDE WITH INSULATION CEMENT AND ALLOWED TO DRY FOR 72 HOURS. THE ASBESTOS CLOTH SHALL BE PAINTED AS REQUIRED BY SUB-PARAGRAPH 319-1.9-3 OF SUB-SECTION 319-1 OF THE GEN. SPECS. THE EDGES OF THE ASBESTOS CLOTH SHALL BE BEVELED WITH ASBESTOS AND PORTLAND CEMENT AS A PROTECTION.
7. THE LOWER FRONT HALF OF EVAPORATORS TO BE COVERED WITH .0313" THICK GALVANIZED SHEET STEEL LAGGING MADE IN FIVE PORTABLE SECTIONS AS SHOWN ON PLAN. EACH SECTION TO BE EASILY REMOVABLE AND HELD TOGETHER WITH ¼" DIA. ROUND HEAD MACHINE SCREWS. SEE NOTE 10A.
8. ALL SCREW THREADS TO BE AMERICAN (NATIONAL) STANDARD FORM COARSE THREAD SERIES.
9. MANUFACTURER'S NAME PLATE TO BE SECURELY FASTENED IN A CONVENIENT PLACE ON THE OUTSIDE OF LAGGING.
10. ALL INSULATION AND CEMENT MUST MEET THE REQUIREMENTS OF GENERAL SPECIFICATIONS SUB-SECTION 319-1 OF JUNE 1, 1940.
- 10A. FOR THE CONSERVATION OF STRATEGIC MATERIALS WHERE STATUS OF WORK PERMITS, SUBSTITUTE "SHEET STEEL - N.D. SPECS. 47-8-10 TYPE I FOR 47-8-10 TYPE II, CLASS "D" FOR PCS 203 & 211. OMIT "GALVANIZE" AND PAINT WITH ZINC CHROMATE PAINT.



ONLY WIRE WHERE IT INTERFERES WITH CONTOUR OF MACHINERY

BLANKET SHAPED TO CONTOUR OF MACHINERY

203

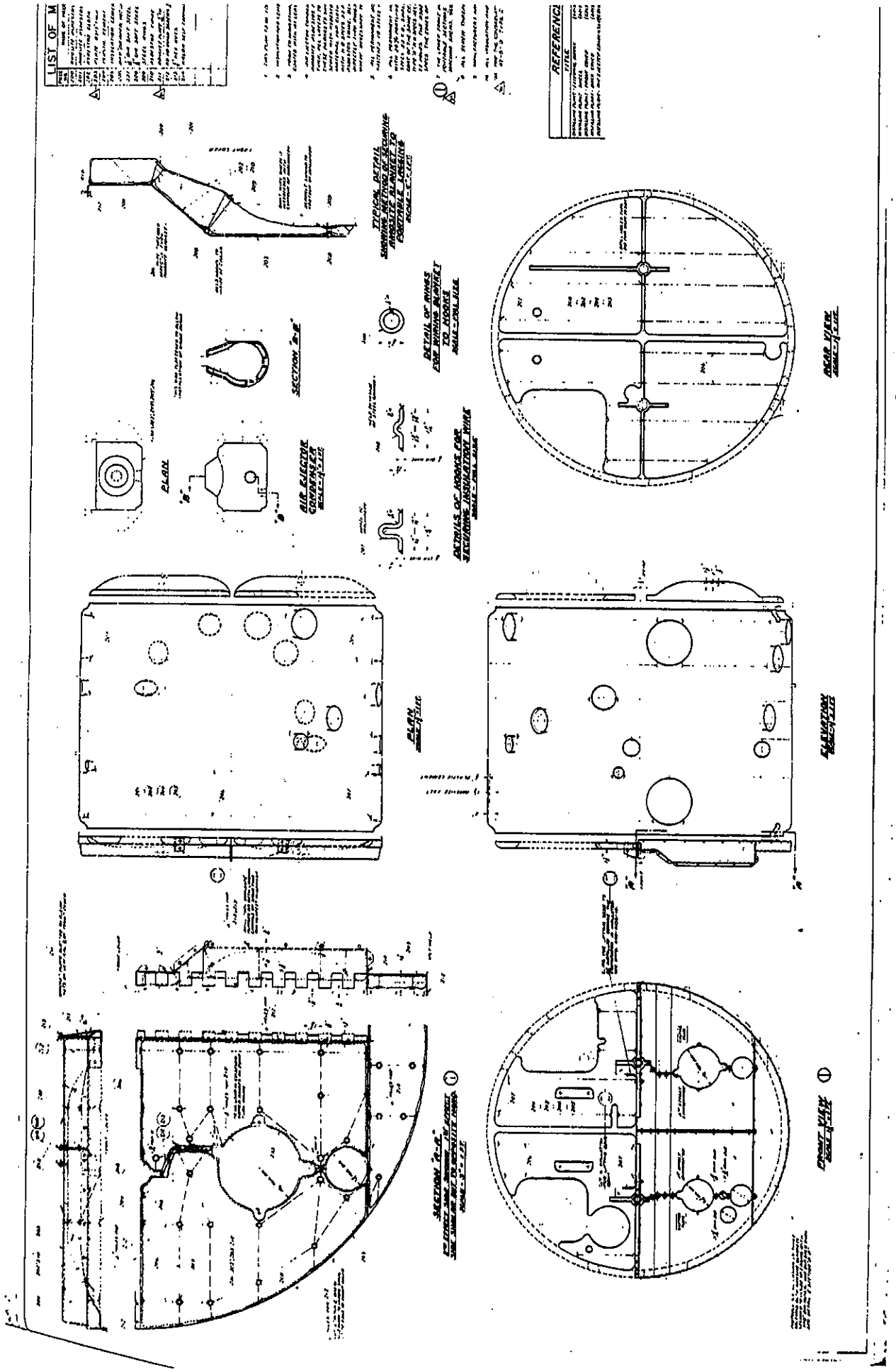
TYPICAL DETAIL METHOD OF SECURING TE BLANKET TO BLE LAGGING (PAT. 6-8-40 LET)

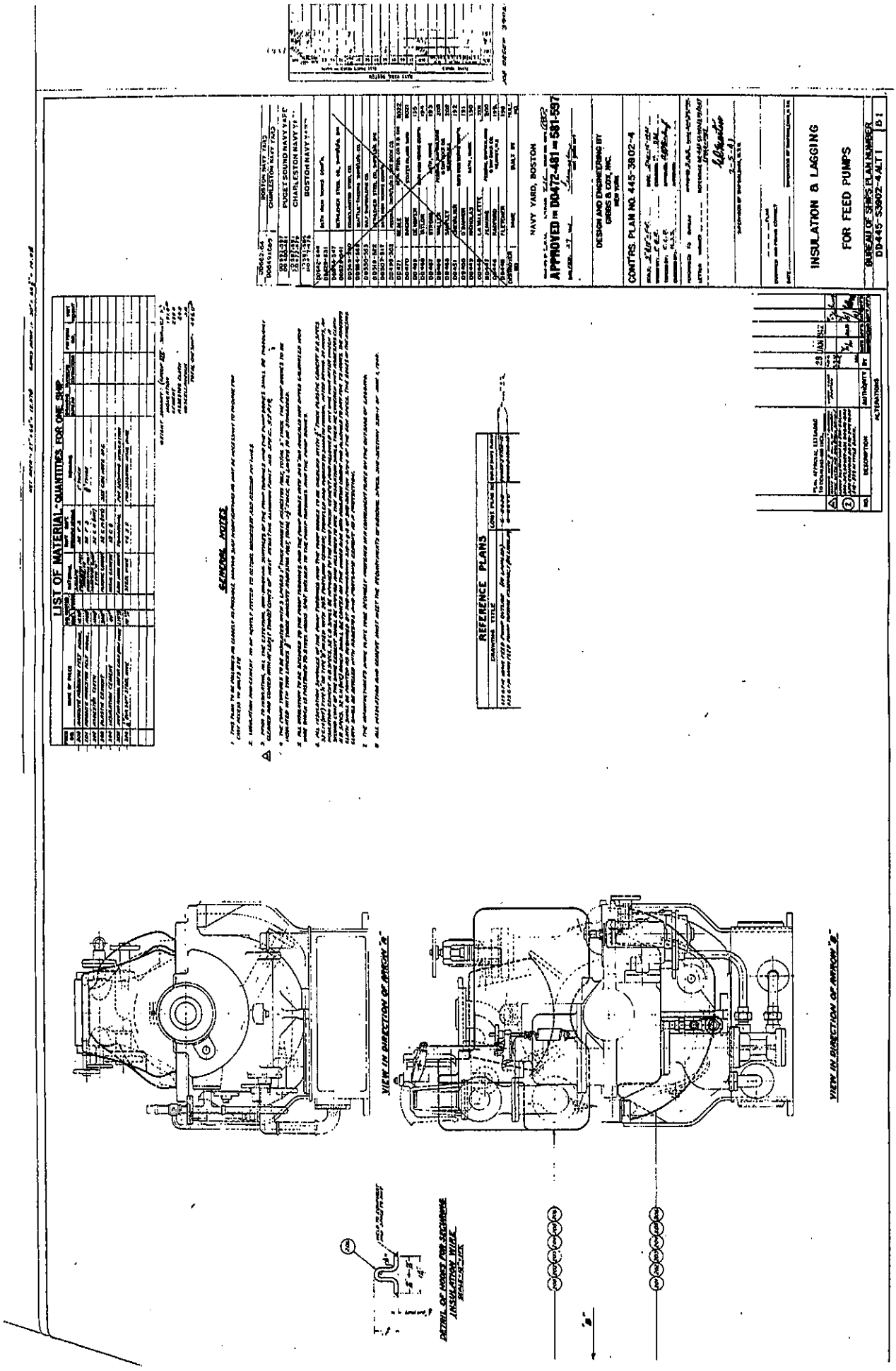
REFERENCE PLANS

TITLE		CONT FILE NO	BuNE DWG NO
DISTILLING PLANT - EXTERNAL ARRGT.	(GRISCOM - RUSSELL)	NYE 1895 - 1A	00995 31801-10
DISTILLING PLANT - SHELL	(GRISCOM - RUSSELL)	NYE 1893 - 3A	00995 31801-11
DISTILLING PLANT - FRONT COVER	(GRISCOM - RUSSELL)	NYE 1893 - 4A	00995-31801-13
DISTILLING PLANT - BACK COVER	(GRISCOM - RUSSELL)	NYE 1893 - 5A	00995 31801-14
DISTILLING PLANT - AIR EJECTOR CONDENSER	(GRISCOM - RUSSELL)	NYE 1893 - 6A	00995 31801-10

NO.	DESCRIPTION	AUTHORITY	BY	DATE	APP'G CONTRACTOR	DATE	APP'G GOVT. REP'L.
1	ADDED NOTE 10A TO GEN. NOTES & NOTE 7 AND TO PIECES 203 & 211 IN LIST	NAVY YARD BOSTON	MCA NEW				
	PLAN AS ALTERED TO [illegible]			29 JAN 1943			
2	ADDED CLIPS AND NOTE FOR LIFTING GEAR ON FRONT OF EVAPORATOR	B.O.S. NEW YORK	MSS MSS	1/16		1/16	
3	FRONT METAL LAGGING SPLIT AND NUMBERED WHERE INDICATED ON FRONT PLATE IN ORDER TO FACILITATE REMOVING & REPLACING LAGGING WITHOUT DISMANTLING RINGS - SPCT FOR & BAR'L NOTE NO 7 CHANGED ACCORDINGLY	B.O.S. NEW YORK	JBP	2/14/44		2/17/44	

ALTERATIONS


LIST OF M
REFERENC
TITLE
TYPICAL DETAIL
SHOWING METHOD OF securing
ACOUSTIC BLANKET TO
CONTROL LOADING
SCALE - 3"=1'0"
DETAIL OF RINGS
FOR WIRING BLANKET
TO HOOKS
SCALE - FULL SIZE
SECTION 2"=1'0"
PLAN
AIR FLEXIBLE
CONDUITS EA
SCALE - 3"=1'0"
DETAILS OF HOOKS FOR
SECURING INSULATION WIRE
SCALE - FULL SIZE
REAR VIEW
SCALE - 3"=1'0"
PLAN
SCALE - 3"=1'0"
ELEVATION
SCALE - 3"=1'0"
SECTION 2"=1'0"
FOR DETAILS OF ACOUSTIC BLANKET
SEE SHEET NO. 2 SCALE - 3"=1'0"
FRONT VIEW
SCALE - 3"=1'0"


INSULATION & LAGGING
FOR FEED PUMPS
BUREAU OF SHIPS PLAN NUMBER
DD445-S3602-4ALT1
APPROVED ON DD472-481 = 581-597
NAVY YARD, BOSTON
DESIGN AND ENGINEERING BY
GIBBS & COX, INC.
CONTRS. PLAN NO. 445-38002-4
LIST OF MATERIAL - QUANTITIES FOR ONE SHIP
REFERENCE PLANS
VIEW IN DIRECTION OF ARROW "A"
VIEW IN DIRECTION OF ARROW "B"
DETAIL OF HOOKS FOR SECURING INSULATION WIRE

NET AREA = 27" x 66" = 12.37 ft² GROSS AREA = 30" x 66 1/2" =

LIST OF MATERIAL-QUANTITIES FOR ONE SHIP

PIECE NO.	NAME OF PIECE	NO. WANTED DRWG. NUMBER	MATERIAL	NAVY DEPT SPECIFICATIONS	REMARKS	DRAWING BUREAU	DRAWING NUMBERS CONTRACTORS	PATTERN NO.	UNIT WEIGHT
200	AMOSITE ASBESTOS FELT INSUL.	1296	AMOSITE ASBESTOS FELT	38 P 3	1" THICK				
201	AMOSITE ASBESTOS FELT INSUL.	1008	AMOSITE ASBESTOS FELT	38 P 3	1/2" THICK				
204	ASBESTOS CLOTH	1008	ASBESTOS CLOTH TYPE "B"	38 C 11 (MIT)					
203	PLASTIC CEMENT	200	PLASTIC CEMENT	38 C M (MIN)	SEE GEN NOTE #6				
204	INSULATION CEMENT	60	INSUL CEMENT	38 C 8					
205	.049" DIA ANNEAL HOT DIP GALV IRON WIRE	275	GALV IRON WIRE	COMMERCIAL	FOR SECURING INSULATION				
206	1/8" DIA SOFT STEEL WIRE	18	STEEL WIRE	96 S 8	FOR SECURING INSUL WIRE				

WEIGHT SUMMARY - (GROUP VII - SUB-GROUP)

INSULATION	191.0
CEMENT	228.9
ASBESTOS CLOTH	24.0
MISCELLANEOUS	3.0
TOTAL ONE SHIP	446.0

GENERAL NOTES

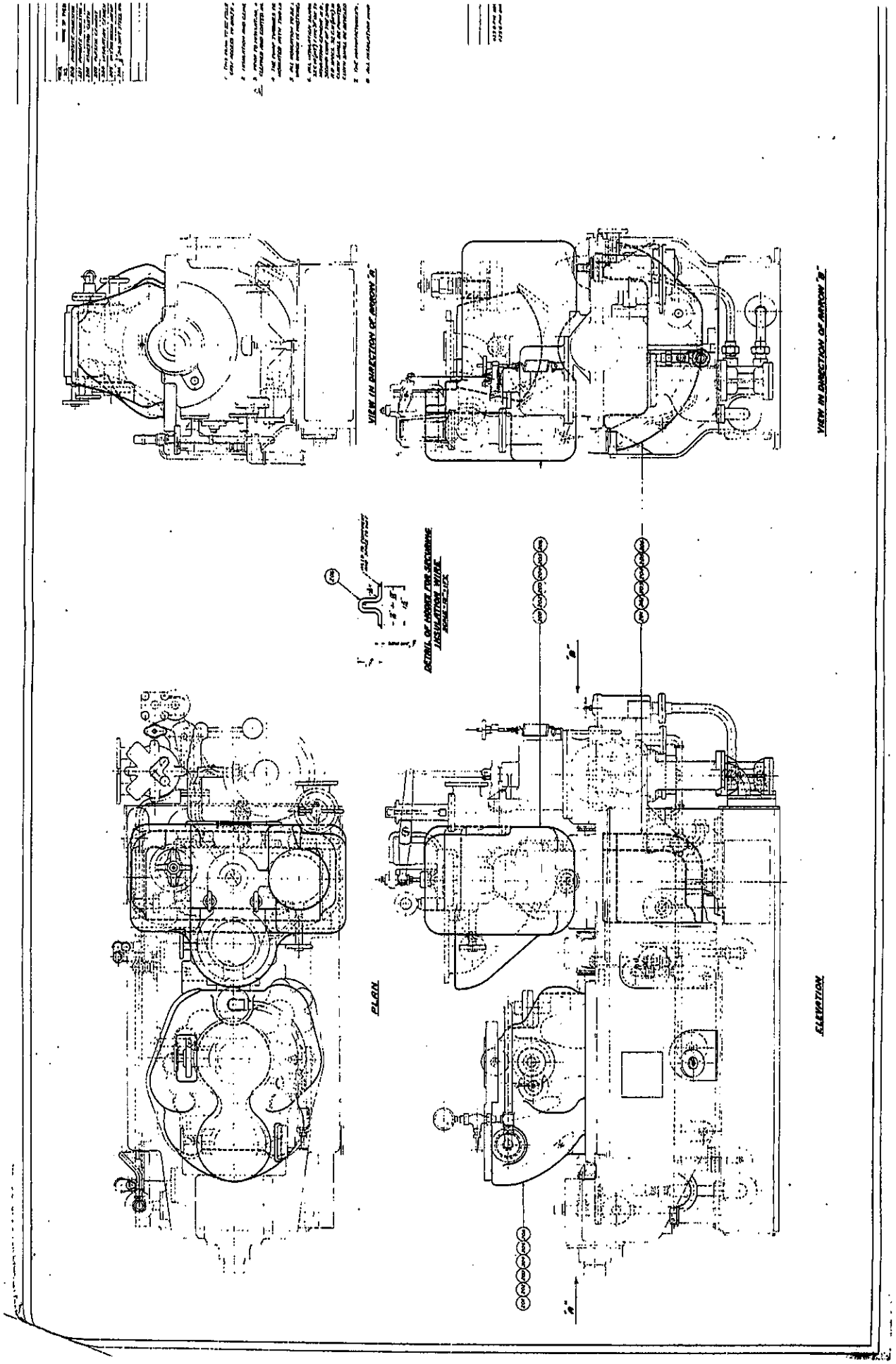
1. THIS PLAN TO BE FOLLOWED AS CLOSELY AS POSSIBLE, MAKING SUCH MODIFICATIONS AS MAY BE NECESSARY TO PROVIDE FOR EASY ACCESS TO BOLTS ETC
2. INSULATION AND CEMENT TO BE NEATLY FITTED TO ACTUAL MACHINERY AND AROUND FITTINGS
3. PRIOR TO INSULATING, ALL THE EXTERNAL NON-WORKING SURFACES OF THE PUMP TURBINES AND THE PUMP BODIES SHALL BE THOROUGHLY CLEANED AND COATED WITH AT LEAST TWO (2) COATS OF HEAT RESISTING ALUMINUM PAINT NO. SPEC. 32 P 19.
4. THE PUMP TURBINES TO BE INSULATED WITH 3 LAYERS 1" THICK AMOSITE ASBESTOS FELT, TOTAL 3" THICK. THE PUMP BODIES TO BE INSULATED WITH TWO LAYERS 1/2" THICK AMOSITE ASBESTOS FELT, TOTAL 1" THICK. ALL LAYERS TO BE STAGGERED.
5. ALL INSULATION TO BE SECURED TO THE PUMP TURBINES AND THE PUMP BODIES WITH .049" DIA ANNEALED HOT DIPPED GALVANIZED IRON WIRE WHICH IS FASTENED TO STEEL HOOKS SPOT WELDED TO THE PUMP TURBINES AND THE PUMP BODIES.
6. ALL INSULATION SURFACES OF THE PUMP TURBINES AND THE PUMP BODIES TO BE OVERLAID WITH 1/2" THICK PLASTIC CEMENT N.D. SPECS. 32 C 14 (INT.) TYPE "B" OR TYPE "A" MIXED WITH 30% PORTLAND CEMENT, TROWELED AND RUBBED TO SMOOTH FINISH. AFTER ARTHING 24 HOURS, AN INSULATION CEMENT N.D. SPECS. 32 C 8 SHALL BE APPLIED TO THE HARD FINISH CEMENT AND ALLOWED TO DRY ONE HOUR AFTER WHICH A SECOND COAT OF THE SAME CEMENT SHALL BE APPLIED AND ALLOWED TO DRY. THE INSULATION SHALL THEN BE COVERED WITH ASBESTOS CLOTH N.D. SPECS. 32 C 11 (MIT) WHICH SHALL BE COATED ON THE UNDER SIDE WITH INSULATION CEMENT AND ALLOWED TO DRY FOR 72 HOURS. THE ASBESTOS CLOTH SHALL BE PAINTED AS REQUIRED BY SUB-PARAGRAPH 313-1-g-2 OF SUB-SECTION 313-1 OF THE GEN SPECS. THE EDGES OF THE ASBESTOS CLOTH SHALL BE BEVELED WITH ASBESTOS AND PORTLAND CEMENT AS A PROTECTION.
7. THE MANUFACTURER'S NAME PLATE TO BE SECURELY FASTENED IN A CONVENIENT PLACE ON THE OUTSIDE OF LAGGING.
8. ALL INSULATION AND CEMENT MUST MEET THE REQUIREMENTS OF GENERAL SPECS. SUB-SECTION 330-1 OF JUNE 1, 1940.

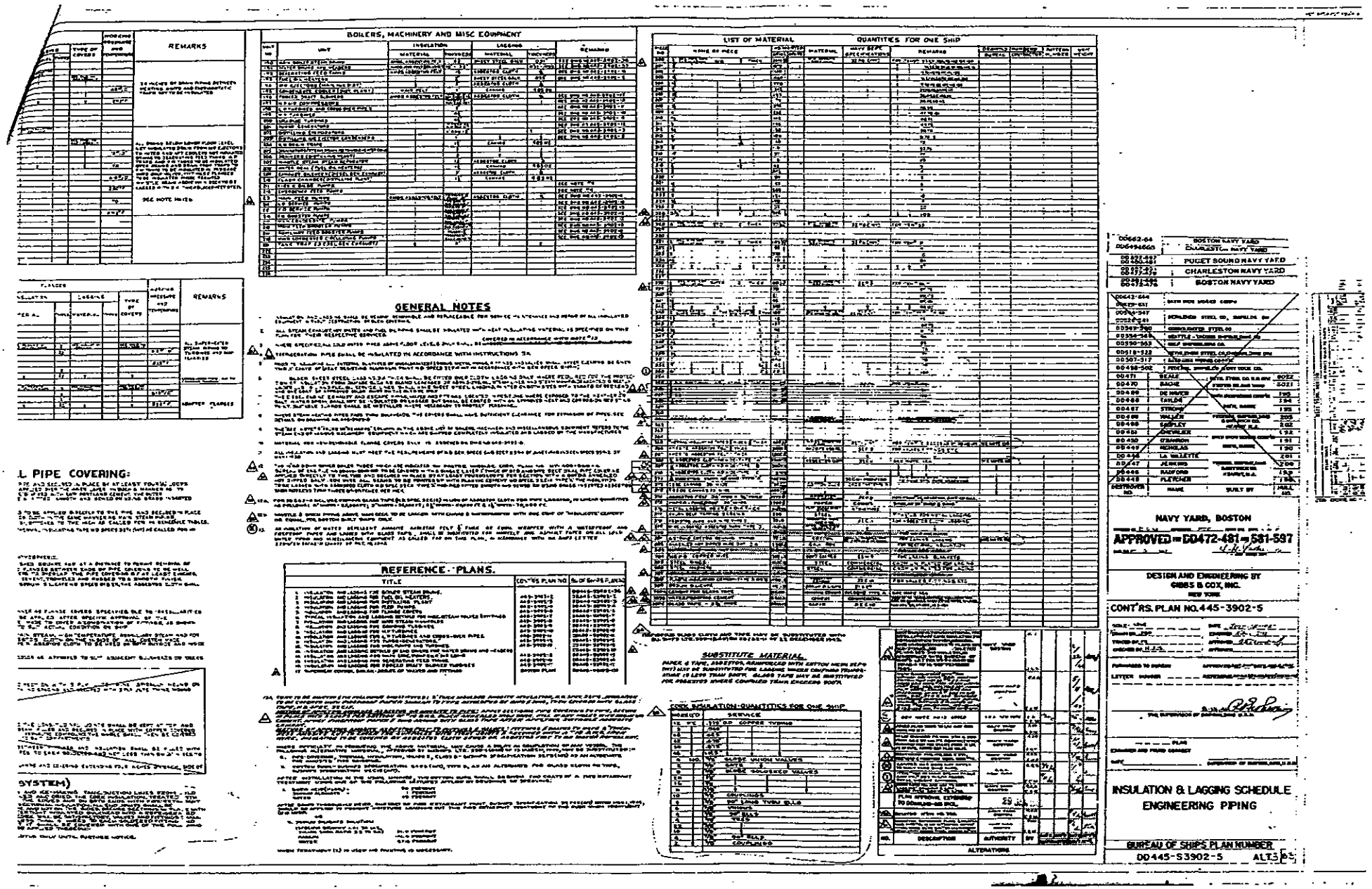
REFERENCE PLANS

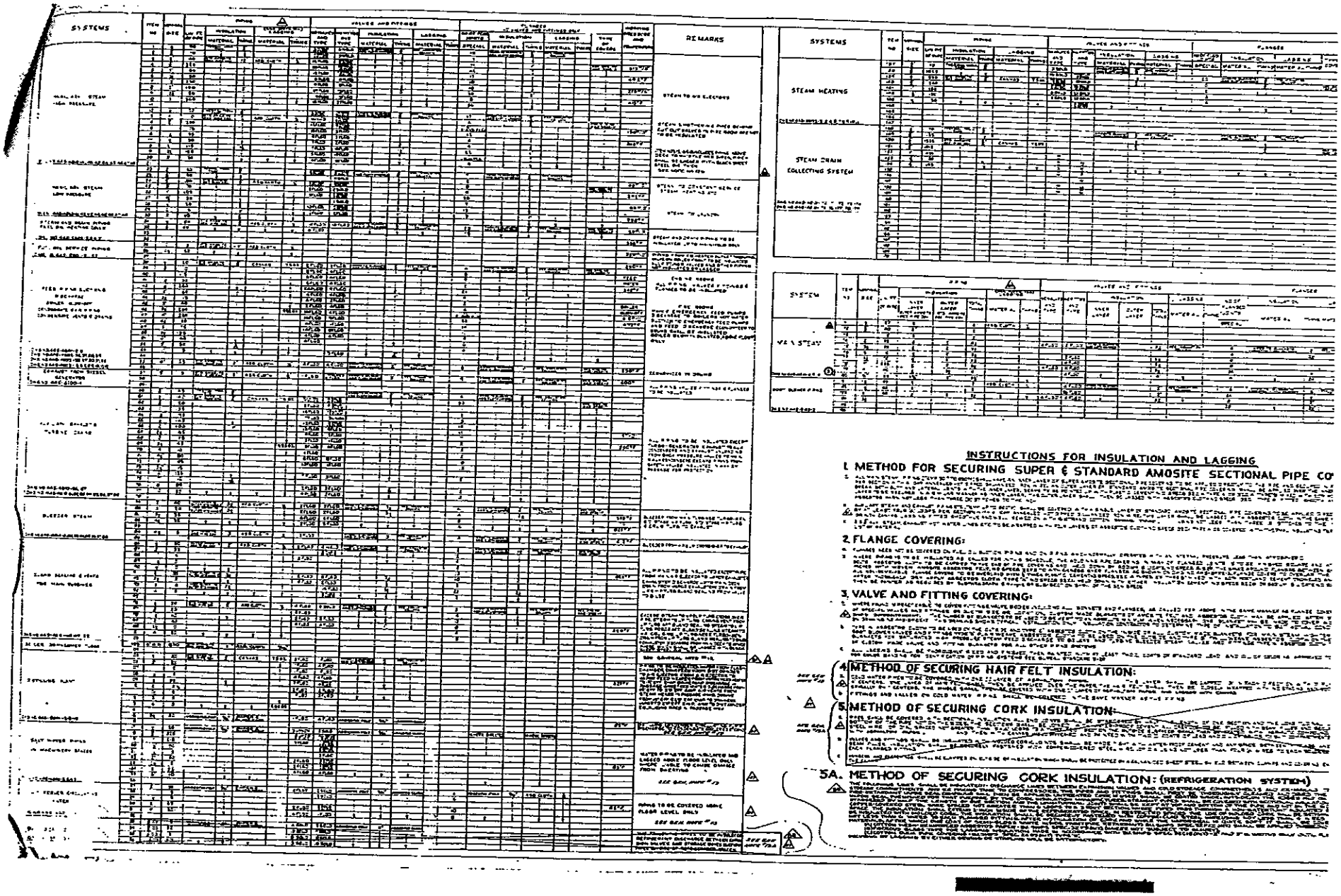
DRAWING TITLE	CONT. PLAN NO.	BUR OF SHIPS PLAN #
925 G.P.M. MAIN FEED PUMP OUTLINE (DE LAVAL CO.)	6-8639	[illegible]
925 G.P.M. MAIN FEED PUMP TURBINE ASSEMBLY (DE LAVAL CO.)	6-8690	[illegible]

NO.	DESCRIPTION	AUTHORITY	BY	DATE	APP'D CONTRACTOR	DATE APP'D NAVY DEPT.
	PLAN APPROVAL EXTENDED TO DD049,042-665 INCL.			29 JAN 1942		
1	ADDED SECTIONS DD 291-310, DD 344-347, DD 629-631, DD 641-644 AND CHANGED DD 316-349 TO DD 316-322 IN TITLE BLOCK.			4/11/41	4/14/41	5/5/41

ALTERATIONS


VIEW IN DIRECTION OF ARROW "A"
VIEW IN DIRECTION OF ARROW "B"
ELEVATION





[redacted]

ST OF MATERIAL — QUANTITIES FOR ONE SHIP

CE	NO. WANTED	MATERIAL	NAVY DEPT. SPECIFICATIONS	REMARKS	DRAWING BUREAU	NUMBERS CONTRACTOR	PATTERN NUMBER	UNIT WEIGHT
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				

TAPE MAY BE SUBSTITUTED WITH IN ES7A5-11 OF 22 DECEMBER 1943.

TUTE MATERIAL

TOS. REINFORCED WITH COTTON MESH 32P9 TED FOR LAGGING WHERE CONFINED TEMPER- 00°F. GLASS TAPE MAY BE SUBSTITUTED CONFINED TEMP EXCEEDS 500°F.

N-QUANTITIES FOR ONE SHIP

SERVICE
COPPER TUBING
OBE UNION VALVES
TE
OBE SOLDERED VALVES
UPLINGS
2" LONG TURN ELLS
NIONS
0° ELLS
TEES
90° ELLS
COUPLINGS

ALTERATIONS

NO.	DESCRIPTION	AUTHORITY	BY	DATE
[illegible]	[illegible]	NAVY YARD BOSTON		
[illegible]	[illegible]	NAVY YARD BOSTON		
[illegible]	SEE NOTE NO 13 ADDED	3RD NEW YORK		
[illegible]	[illegible]	NAVY YARD BOSTON		
[illegible]	[illegible]	NAVY YARD BOSTON		
[illegible]	[illegible]	NAVY YARD BOSTON		
[illegible]	[illegible]	NEW YORK		
[illegible]	[illegible]	NAVY YARD BOSTON		
[illegible]	PLAN APPROVAL EXTENDED TO DD640,682-685 INCL.			29 JUL
[illegible]	DELETED ITEM NO. 316	NAVY YARD BOSTON		
[illegible]	[illegible]	NAVY YARD BOSTON		

DD682-84 DD649&655	BOSTON NAVY YARD CHARLESTON NAVY YARD
DD692-697 DD480-481	PUGET SOUND NAVY YARD
DD597-691 DD477-479	CHARLESTON NAVY YARD
DD581-586 DD472-476	BOSTON NAVY YARD

DESTROYER NO.	NAME	BUILT BY	HULL NO.
DD642-644 DD629-631		BATH IRON WORKS CORPN.	
DD544-547 DD526-541		BETHLEHEM STEEL CO., SHIPBLDG DIV.	
DD569-580		CONSOLIDATED STEEL CO	
DD554-568		SEATTLE - TACOMA SHIPBUILDING CO.	
DD550-553		GULF SHIPBUILDING CO.	
DD518-522		BETHLEHEM STEEL CO, SHIPBUILDING DIV.	
DD507-517		BATH IRON WORKS CORPN.	
DD498-502		FEDERAL SHIPBLD'G & DRY DOCK CO.	
DD471	BEALE	BETH. STEEL CO. S.B. DIV. STATEN ISLAND YARD	8022
DD470	BACHE		8021
DD469	DE HAVEN	BATH IRON WORKS CORPN. BATH, MAINE	195
DD468	TAYLOR		194
DD467	STRONG		193
DD466	WALLER	FEDERAL SHIPBUILDING & DRY DOCK CO. KEARNY N.J.	203
DD465	SAUFLEY		202
DD451	CHEVALIER	BATH IRON WORKS CORPN. BATH, MAINE	192
DD450	O'BANNON		191
DD449	NICHOLAS		190
DD448	LA VALLETTE	FEDERAL SHIPBUILDING & DRYDOCK CO. KEARNY, N.J.	201
DD447	JENKINS		200
DD446	RADFORD		199
DD445	FLETCHER		198

NAVY YARD, BOSTON

APPROVED FOR DD472-481 AND 581-597

DESIGN AND ENGINEERING BY
GIBBS & COX, INC.
NEW YORK

CONT'RS. PLAN NO. 445-3902-5

SCALE: NONE
DRAWN BY: [illegible]
TRACED BY: [illegible]
CHECKED BY: H.J.S.
DATE: JULY 15-1941
EXAMINED: [illegible]
APPROVED: [illegible]
APPROVED:

FORWARDED TO BUREAU
LETTER NUMBER
APPROVED BUR. SHIPS DATE [illegible]
REFERENCE [illegible]

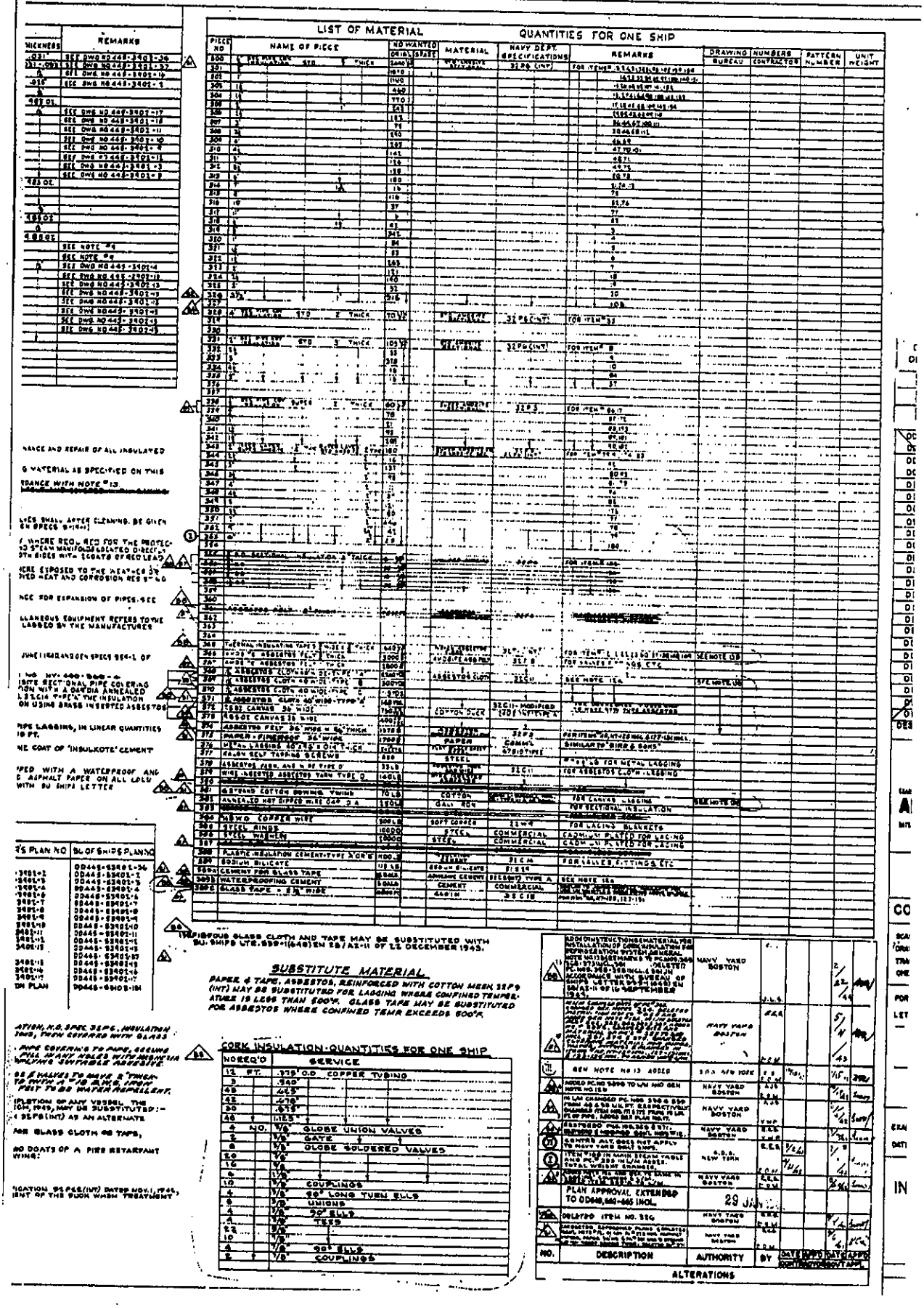
B.I.W. [signature]
FOR SUPERVISOR OF SHIPBUILDING U.S.N.

EXAMINED AND FOUND CORRECT — PLAN
DATE — SUPERVISOR OF SHIPBUILDING, U.S.N.

INSULATION & LAGGING SCHEDULE ENGINEERING PIPING

BUREAU OF SHIPS PLAN NUMBER
DD445-S3902-5 ALT.3 [illegible]

NAVY YARD, BOSTON


LIST OF MATERIAL
QUANTITIES FOR ONE SHIP
NAME OF PIECE
MATERIAL
NAVY DEPT. SPECIFICATIONS
REMARKS
DRAWING NUMBERS
BUREAU
CONTRACTOR
PATTERN NUMBER
UNIT WEIGHT
THICKNESS
REMARKS
LIST OF SHIPS PLANNING
SUBSTITUTE MATERIAL
PAPER & TAPE, ASBESTOS, REINFORCED WITH COTTON MESH, 38F9 (INT) MAY BE SUBSTITUTED FOR LAGGING WHERE CONFINED TEMPERATURE IS LESS THAN 600°F. GLASS TAPE MAY BE SUBSTITUTED FOR ASBESTOS WHERE CONFINED TEMP EXCEEDS 600°F.
CORK INSULATION QUANTITIES FOR ONE SHIP
NO REQ'D
SERVICE
12 FT. .375" O.D. COPPER TUBING
3 .540"
46 .465"
42 .410"
30 .675"
46 1.125"
4 NO. 1/8 GLOBE UNION VALVES
2 1/8 GATE
8 1/8 GLOBE SOLDERED VALVES
50 1/8
10 1/8
4 1/8
10 1/8 COUPLINGS
4 1/8 90° LONG TURN ELLS
8 1/8 UNIONS
4 1/8 90° ELLS
4 1/8 TEES
52 1/8
10 1/8
4 1/8 90° ELLS
2 1/8 COUPLINGS
ALTERATIONS
NO.
DESCRIPTION
AUTHORITY
BY
DATE

WORKING PRESSURE AND TEMPERATURE	REMARKS
	24 INCHES OF DRAIN PIPING BETWEEN HEATING UNITS AND THERMOSTATIC TRAPS NOT TO BE INSULATED
	ALL DRAINS BELOW LOWER FLOOR LEVEL NOT INSULATED DRAIN FROM AIR EJECTORS TO INTER AND AFT COOLERS NOT INSULATED DRAINS TO DEAERATING FEED TANKS H.P TRAPS AND FW TANKS TO BE INSULATED DECK DRAINS AND DRAIN FROM TRAPS TO F.W TANKS TO BE INSULATED IN ENGINE ROOM ONLY VALVES, FITTINGS & FLANGES TO BE INSULATED WHERE REQUIRED. WHISTLE DRAIN ABOVE MAIN DECK TO BE LAGGED WITH 014" THICK BLACK SHEET STEEL. SEE NOTE No.12b

NO	TYPE OF COVERS	WORKING PRESSURE AND TEMPERATURE	REMARKS
			ALL SUPERHEATED STEAM PIPING TO TURBINES AND AUXILIARIES
			EXHAUST PIPING NOT TO EXCEED 150°F
			ADAPTER FLANGES

BOILERS, MACHINERY AND MISC EQUIPMENT

UNIT NO	UNIT	INSULATION MATERIAL	INSULATION THICKNESS	LAGGING MATERIAL	LAGGING THICKNESS	REMARKS
140	MAIN BOILER STEAM DRUMS	AMOS. ASBESTOS FELT	2"	SHEET STEEL GALV	.031"	SEE DWG NO 445-3402-36
141	WATER DRUMS AND HEADERS	AMOS ASB. FELT & ASBESTOS CLOTH	1½" & 2"		.031-.093	SEE DWG NO 445-3402-37
142	DEAERATING FEED TANKS	AMOS ASBESTOS FELT	1½"	ASBESTOS CLOTH	A	SEE DWG NO 445-3402-16
143	FUEL OIL HEATERS		2"	SHEET STEEL GALV	.016"	SEE DWG NO 445-3402-16
144	AIR EJECTORS (MAIN, AUX, DIST)		1"	ASBESTOS CLOTH	A	SEE DWG NO 445-3402-1
145	CONDENSATE COOLER (DIST. PLANT)	MAIN FELT	1"	CANVAS	4.85 OZ.	
146	FORCED DRAFT BLOWERS	AMOS ASBESTOS FELT	1½" & 2"	ASBESTOS CLOTH	A	SEE DWG NO 445-3402-17
147	H.P AIR COMPRESSORS		1½" & 2"			SEE DWG NO 445-3402-18
148	L.P TURBINES AND CROSS-OVER PIPES		1½" & 2"			SEE DWG NO 445-3402-11
149	H.P TURBINES		1"			SEE DWG NO 445-3402-10
150	CRUISING TURBINES		2½"			SEE DWG NO 445-3402-9
151	TURBO GENERATORS		2½"			SEE DWG NO 445-3402-16
202	DISTILLING EVAPORATORS		1" & 2½"			SEE DWG NO 445-3402-3
203	DISTILLING AIR EJECTOR CONDENSERS		1"			SEE DWG NO 445-3402-3
204	H.P DRAIN TRAPS		1"	CANVAS	4.85 OZ.	
205	DRAINTANKS (STEAM DRAIN TO TANKS HEATED ONLY)		1"			
206	DRAINERS (DISTILLING PLANT)		1"	ASBESTOS CLOTH	A	
207	WHISTLE STEAM, STEAM SEPARATOR		1"	CANVAS	4.85 OZ.	
208	WATER SEAL (FUEL OIL HEATERS)		1"	ASBESTOS CLOTH	A	
209	EXHAUST SILENCER (DIESEL GEN EXHAUST)		1"	CANVAS	4.85 OZ.	
210	FLASH CHAMBER (DISTILLING PLANT)		1"	ASBESTOS CLOTH	A	
211	FIRE & BILGE PUMPS		1"	CANVAS	4.85 OZ.	
212	EMERGENCY FEED PUMPS					SEE NOTE #4
213	MAIN FEED PUMPS	AMOS. ASBESTOS FELT	1½" & 2"	ASBESTOS CLOTH	A	SEE NOTE #4
214	L.O SERVICE PUMPS		1"			SEE DWG NO 445-3401-6
215	F.O SERVICE PUMPS		1"			SEE DWG NO 445-3401-11
216	F.O BOOSTER PUMPS		1"			SEE DWG NO 445-3401-11
217	MAIN CONDENSATE PUMPS		1"			SEE DWG NO 445-3401-1
218	MAIN FEED BOOSTER PUMPS		1"			SEE DWG NO 445-3401-13
219	AUXILIARY FEED BOOSTER PUMPS		1"			SEE DWG NO 445-3401-1
220	MAIN CONDENSER CIRCULATING PUMPS		1"			SEE DWG NO 445-3401-9
221	TANK TRAP (DIESEL GEN EXHAUST)		1"			SEE DWG NO 445-3401-5
222						
223						
224						
225						
226						

GENERAL NOTES

1. INSULATION AND LAGGING SHALL BE READILY REMOVABLE AND REPLACEABLE FOR SERVICE MAINTENANCE AND REPAIR OF ALL INSULATED EQUIPMENT WITHOUT DESTRUCTION OF SUCH COVERING.
2. ALL STEAM, EXHAUST, HOT WATER AND FUEL OIL PIPING SHALL BE INSULATED WITH HEAT INSULATING MATERIAL AS SPECIFIED ON THIS PLAN FOR THEIR RESPECTIVE SERVICES.
3. WHERE SPECIFIED, ALL COLD WATER PIPES ABOVE FLOOR LEVELS ONLY SHALL BE COVERED IN ACCORDANCE WITH NOTE #13.
4. REFRIGERATION PIPES SHALL BE INSULATED IN ACCORDANCE WITH INSTRUCTIONS 5A.
5. PRIOR TO INSULATING ALL EXTERNAL SURFACES OF UNGALVANIZED FERROUS METAL PIPING, FITTINGS AND VALVES SHALL AFTER CLEANING BE GIVEN TWO (2) COATS OF HEAT RESISTING ALUMINUM PAINT NO SPECS SEPIA PAINT IN ACCORDANCE WITH GEN SPECS 9(INT.)
6. BLACK SHEET STEEL LAGGING 0.014 THICK SHALL BE FITTED OVER CLOTH LAGGING ONLY WHERE REQUIRED FOR THE PROTECTION OF INSULATION FROM DAMAGE SUCH AS BLAND LEAKAGES OR ABRASIONS. ALL STEAM LINES AND STEAM MANIFOLDS ISOLATED DIRECTLY UNDER 2-B, F AND FUEL OIL SERVICE SHALL HAVE SHEET STEEL LAGGING PAINTED ON BOTH SIDES WITH 2 COATS OF RED LEAD AND ONE COAT OF APPROVED COLOR PAINT ON THE OUTSIDE ONLY.
7. THE DIESEL ENGINE EXHAUST AND ESCAPE PIPING, VALVES AND FITTINGS LOCATED IN POSITIONS WHERE EXPOSED TO THE WEATHER OR SALT WATER SPRAY, SHALL NOT BE INSULATED OR LAGGED BUT SHALL BE COATED WITH AN APPROVED HEAT AND CORROSION RESISTING PAINT. SUITABLE GUARDS SHALL BE INSTALLED WHERE NECESSARY TO PROTECT PERSONNEL.
8. WHERE STEAM HEATING PIPES PASS THRU BULKHEADS THE COVERS SHALL HAVE SUFFICIENT CLEARANCE FOR EXPANSION OF PIPES SEE DETAILS ON DRAWING NO. 445-3402-8
9. THE "SEE NOTE #" FOUND IN THE "REMARKS" COLUMN IN THE ABOVE LIST OF BOILERS, MACHINERY AND MISCELLANEOUS EQUIPMENT REFERS TO THE STEAM END OF VARIOUS MACHINERY EQUIPMENT WHICH ARE SHIPPED COMPLETELY INSULATED AND LAGGED BY THE MANUFACTURER.
10. MATERIAL FOR NON-REMOVABLE FLANGE COVERS ONLY IS ORDERED ON DWG NO 445-3402-8.
11. ALL INSULATION AND LAGGING MUST MEET THE REQUIREMENTS OF N.D BEN. SPECS SUB SECT 63411 OF JUNE 1, 1942 AND GEN SPECS 954-1 OF MAY 1, 1938.
12. THE 4" OD DOWN COMER BOILER TUBES WHICH ARE INDICATED ON BOSTON WHEELER CORP. PLAN NO NY-400-508-6, BUREAU OF SHIPS FILE NO 00448-8802/100 TO BE COVERED WITH A SINGLE LAYER 1" THICK OF 85% AMOSITE SECTIONAL PIPE COVERING APPLIED DIRECTLY TO THE TUBE AND SECURED IN PLACE BY AT LEAST FOUR (4) LOOPS PER SECTION, WITH A GARDIA ANNEALED HOT DIPPED GALV. IRON WIRE. ALL SEAMS TO BE POINTED UP WITH PLASTIC CEMENT NO SPECS. 52C(1) TYPE I. THE INSULATION TO BE LAGGED WITH ASBESTOS CLOTH NO SPEC. 51C(1) TYPE A MODIFIED FITTED SMOOTH AND SEWED ON USING BRASS INSERTED YARN NOTLESS THAN THREE (3) STITCHES PER INCH.
- 12a. FOR BS 662-40 INCL. USE FIBROUS GLASS TAPE (NO. SPEC. 52C(1)) IN LIEU OF ASBESTOS CLOTH FOR PIPE LAGGING, IN LINEAR QUANTITIES AS FOLLOWS: 4" WIDTH - 25,000 FT; 3" WIDTH - 35,000 FT; 2½" WIDTH - 60,000 FT & 1½" WIDTH - 70,000 FT.
- 12b. WHISTLE & SIREN PIPING ABOVE MAIN DECK TO BE LAGGED WITH CANVAS & WATERPROOFED WITH ONE COAT OF "INSULKOTE" CEMENT OR EQUAL. FOR BOSTON BUILT SHIPS ONLY.
13. AN INSULATION OF WATER REPELLENT AMOSITE ASBESTOS FELT 2" THICK OR EQUAL WRAPPED WITH A WATERPROOF AND FIREPROOF PAPER AND LAGGED WITH GLASS TAPE, SHALL BE SUBSTITUTED FOR HAIRFELT AND ASPHALT PAPER ON ALL COLD WATER PIPING AND MISCELLANEOUS EQUIPMENT AS CALLED FOR ON THIS PLAN, IN ACCORDANCE WITH BU SHIPS LETTER S33-1/EN ES/A2-11 (3448) OF OCT. 15, 1942.

REFERENCE PLANS.

	TITLE	CONTRS PLAN NO	BU OF SHIPS PLANS NO
1	INSULATION AND LAGGING FOR BOILER STEAM DRUMS.		00448-83401-36
2	INSULATION AND LAGGING FOR FUEL OIL HEATERS.	445-3401-2	00448-83401-37
3	INSULATION AND LAGGING FOR DISTILLING PLANT	445-3401-3	00448-83401-3
4	INSULATION AND LAGGING FOR FEED PUMPS.	445-3401-4	00448-83401-4
5	INSULATION AND LAGGING FOR FLANGE COVERS	445-3401-5	00448-83401-5
6	TYPICAL INSULATION AND LAGGING DETAILS FOR MISC STEAM VALVES & FITTINGS	445-3401-6	00448-83401-6
7	INSULATION AND LAGGING FOR MAIN STEAM MANIFOLDS	445-3401-7	00448-83401-7
8	INSULATION AND LAGGING FOR CRUISING TURBINES.	445-3401-8	00448-83401-8
9	INSULATION AND LAGGING FOR H.P TURBINES	445-3401-9	00448-83401-9
10	INSULATION AND LAGGING FOR L.P TURBINES AND CROSS-OVER PIPES.	445-3401-10	00448-83401-10
11	INSULATION AND LAGGING FOR TURBO-GENERATORS.	445-3401-11	00448-83401-11
12	INSULATION AND LAGGING FOR MISC PUMPS AND TURBINES.	445-3401-12	00448-83401-12
13	INSULATION AND LAGGING DETAILS OF END COVERS FOR WATER DRUMS AND HEADERS.	445-3401-13	00448-83401-13
14	INSULATION AND LAGGING FOR MAIN CIRC. PUMP & H.R AIR COMP.	445-3401-14	00448-83401-14
15	INSULATION AND LAGGING FOR DEAERATING FEED TANKS.	445-3401-15	00448-83401-15
16	INSULATION AND LAGGING FOR FORCED DRAFT BLOWER TURBINES	445-3401-16	00448-83401-16
17	SUPERHEAT CONTROL BOILER ARRGT. OF VALVES AND FITTINGS	445-3401-17	00448-83401-17
		BOSTON PLAN	00448-68103-101

13A. CORK TO BE OMITTED & THE FOLLOWING SUBSTITUTED: 2" THICK MOULDED AMOSITE INSULATION, N.D. SPEC 52 P6. INSULATION TO BE COVERED WITH FIREPROOF PAPER SIMILAR TO TYPE DEVELOPED BY BIRD & SON'S, THEN COVERED WITH GLASS TAPE, N.D. SPEC. 52 C(2).

~~BINDING OF ADJOINING AMOSITE AS REQUIRED OR AMOSITE TO PIPE:~~ APPLY SECTIONAL PIPE COVERING TO PIPE, SECURE WITH ALUM. BANDS IN SECTION OF 12 INS. BLACK ANNEALED IRON WIRE, FILL IN AND HOLES WITH AMOSITE CEMENT. APPLY FIREPROOF PAPER & WIND STRIPS WITH GLASS TAPE AFTER APPLYING SUITABLE ADHESIVE CEMENT.

~~METHOD OF APPLYING AMOSITE ASBESTOS CLOTH TO FITTINGS & VALVES:~~ FITTINGS & VALVES TO HAVE 2" THICK AMOSITE CUT TO OBTAIN THE SURFACE OF THE FITTING AS SECURED ABOVE & WIRED WITH 16 GAUGE IRON WIRE. INSULATION TO BE COVERED BY ASBESTOS CLOTH SEWED ON. ASBESTOS FELT TO BE WATER REPELLENT.

WHERE DIFFICULTY IN PROCURING THE ABOVE MATERIAL MAY CAUSE A DELAY IN COMPLETION OF ANY VESSEL, THE FOLLOWING ALTERNATIVE MATERIAL, APPROVED BY BUSHIPS LTR. S99-1(648) OF 15 MARCH, 1943, MAY BE SUBSTITUTED:-

a. PIPE COVERING, THERMAL INSULATION, GRADE I, CLASS B- BUSHIPS SPECIFICATION 52P6(INT) AS AN ALTERNATE FOR AMOSITE PIPE COVERING.

b. COTTON DUCK - BUSHIPS SPECIFICATION 54D (INT), TYPE B, AS AN ALTERNATE FOR GLASS CLOTH OR TAPE.

AFTER INSTALLATION IN THE USUAL MANNER, THE COTTON DUCK SHALL BE GIVEN TWO COATS OF A FIRE RETARDANT TREATMENT CONSISTING OF THE FOLLOWING MIXTURES APPLIED BY BRUSHING OR SPRAYING:

1. BORIC ACID (H3BO3) - 50 PERCENT
   SODIUM ALGINATE - 1 PERCENT
   WATER - 49 PERCENT

AFTER BEING THOROUGHLY DRIED, ONE COAT OF FIRE RETARDANT PAINT, BUSHIPS SPECIFICATION 52 P66(INT) DATED NOV 1, 1943, SHOULD BE APPLIED TO PREVENT MOISTURE LEACHING OUT THE FIRE RETARDANT TREATMENT OF THE DUCK WHEN TREATMENT (1) IS USED.

OR

2. SODIUM SILICATE SOLUTION
   (SPECIFIC GRAVITY 1.41 TO 1.42, SILICA SODA RATIO 2.2 TO 2.4) - 51.0 PERCENT
   KAOLIN - 41.4 PERCENT
   WATER - 7.6 PERCENT

WHEN TREATMENT (2) IS USED NO PAINTING IS NECESSARY.

RING:

E BY AT LEAST FOUR (4) LOOPS ER IN SUCH A MANNER AS TO ND CEMENT. THE OUTER EWED ON USING BRASS INSERTED

TO THE PIPE AND SECURED IN PLACE ER AS MAIN STEAM PIPING, AS CALLED FOR IN SCHEDULE TABLES.

) SPECS 39Y1 (INT) AS CALLED FOR IN

ISTANCE TO PERMIT REMOVAL OF OF PIPE COVERING TO BE WELL COVERING BY AT LEAST 2 INCHES. ISHED TO A SMOOTH FINISH. 31&24, THE ASBESTOS CLOTH SHALL

SPECIFIED DUE TO IRREGULARITIES FIC APPROVAL BY THE SITUATION OF FITTINGS, AS SHOWN G ON SHIP

ATURE AUXILIARY STEAM AND FOR IDE OF ALL CUSTOM MADE S USED ON BOTH OUTSIDE AND INSIDE

" ADJACENT BULKHEADS OR DECKS

USE TWINE SPIRALLY WOUND ON 3 IN 3 PLY JUTE TWINE WOUND

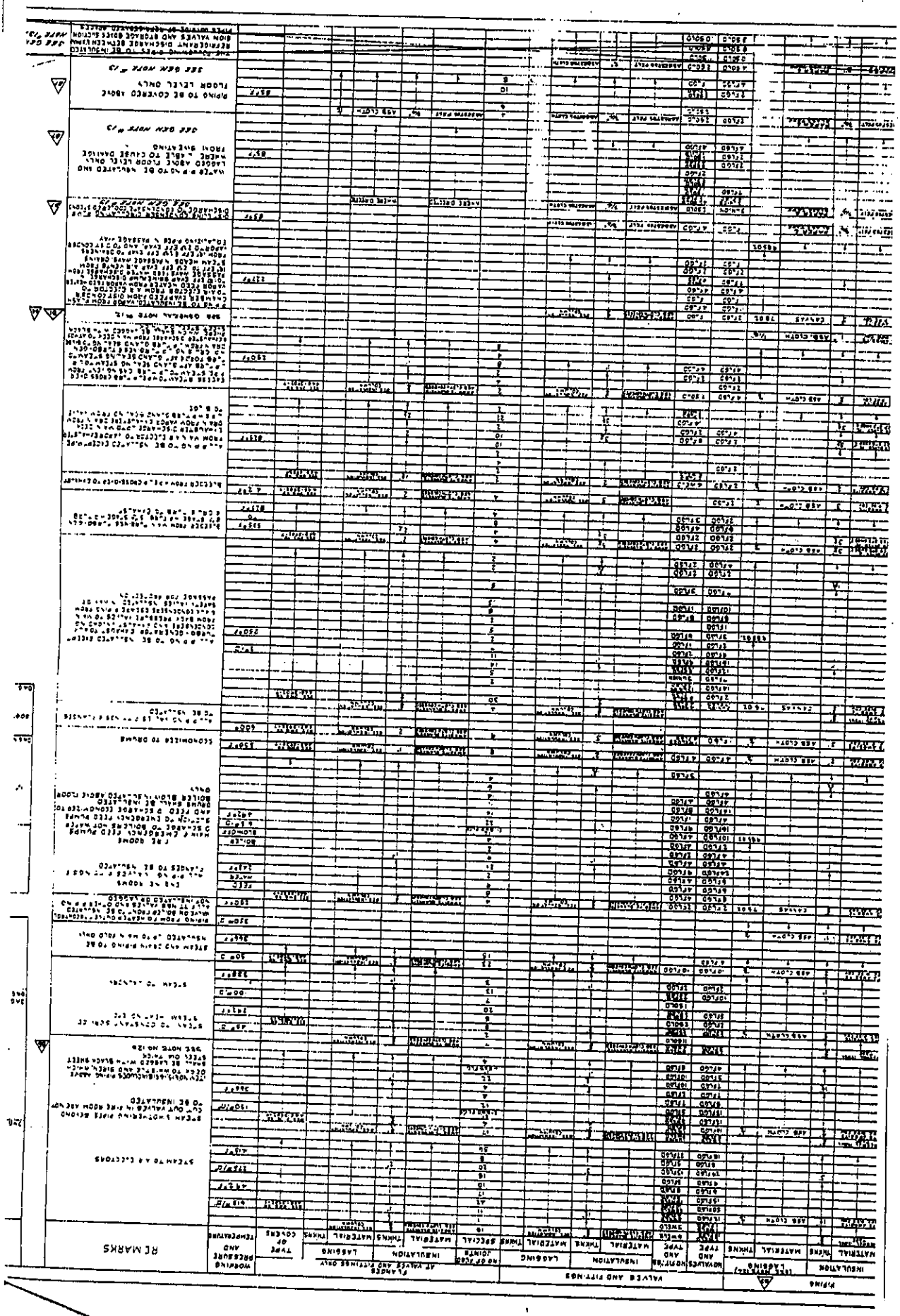
'E SHALL BE KEPT AT TOP AND N PLACE WITH COPPER COVERED WHOLE SHALL THEN BE COVERED

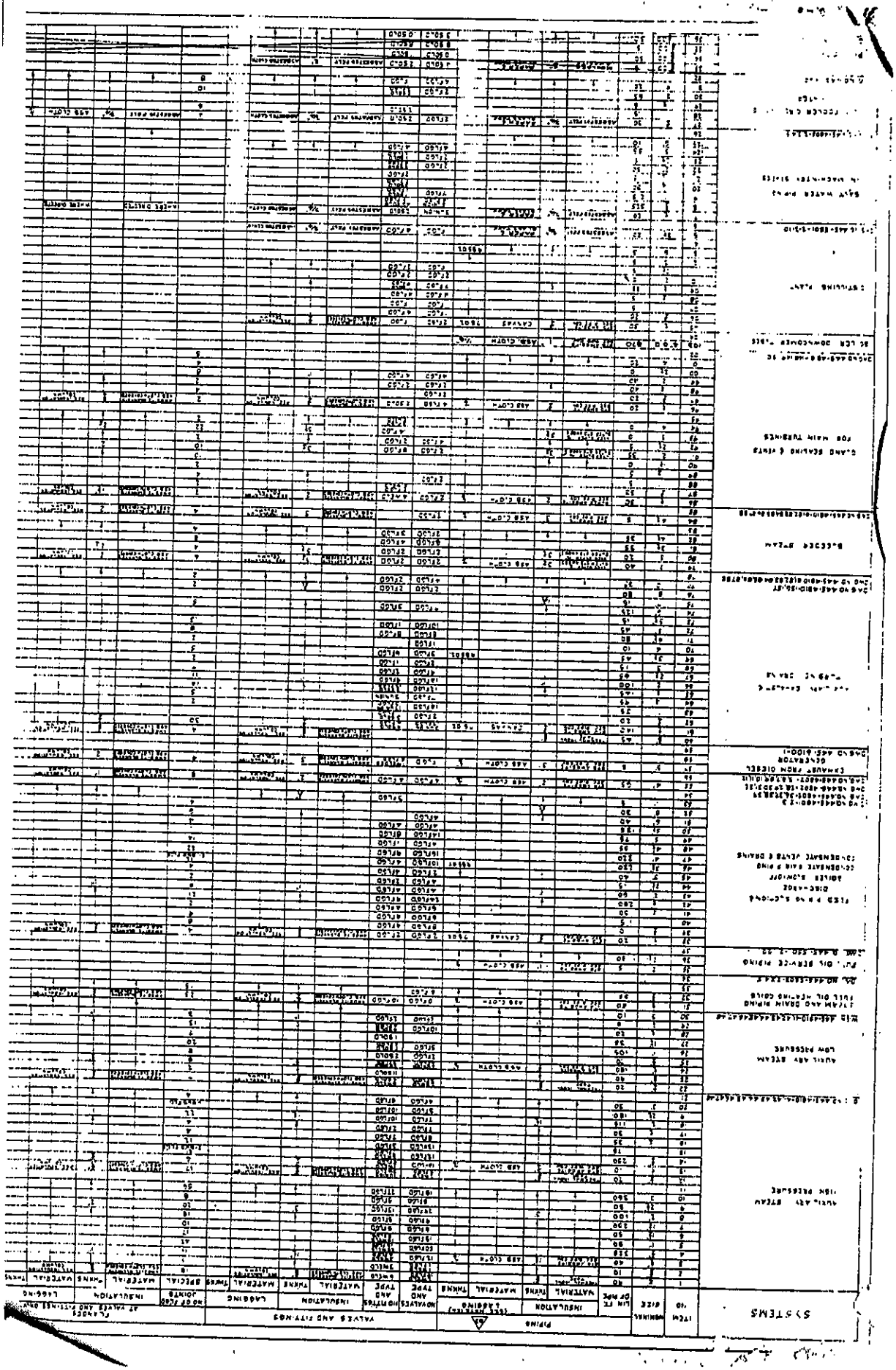
SULATION SHALL BE FILLED WITH NO NOT LESS THAN SIX (6) A FEE TO

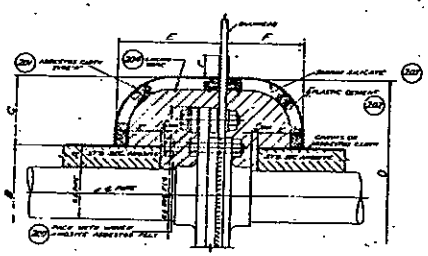
DING FOUR INCHES ON EACH SIDE OF

SUCTION LINES FROM TANK K INSULATION. TREATED WITH H END JOINTS SHALL BE SECURE SECTIONS IN PLACE WITH HEAD INTO A REFRIGERATED EV, VALVES AND FITTINGS SHALL EACH SOLDERED FITTING AND D WITH ONE OF THE FOLLOWING

ER NOTICE.







AUX. LINES-150# PRESS. BULKHEAD FLANGE COVER
TEMP. 400°F. TO 700°F.

LIST OF MATERIAL - QUANTITIES FOR ONE SHIP

ITEM NO.	NAME OF ITEM	TOTAL REQUIRED	MATERIAL	TOTAL SIZE	DIMENSIONS OR CATALOG DESIGNATION	REMARKS	ALLOWED OVERSIZE	ALLOWED OVERWEIGHT %	PATTERN NO.	UNIT WEIGHT
200	MINERAL ASBESTOS CEMENT				32 F 3	1" THICK				
201	LAGGING CLOTH - ASBESTOS				32 C 11					
202	PLASTIC CEMENT				32 C 14	SEE CONTRACT NOTE BELOW				
203	SODIUM SILICATE				32 C 29					
204	#14 B&S COPPER WIRE				72 W 5	FOR LAGGING				
205	MINERAL ASBESTOS FELT ROLL				32 F 5	3/4" THICK				

GENERAL NOTES

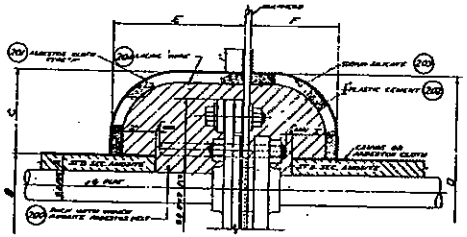
1. [illegible] SHOWN FLANGE COVERS THAT ARE TO HAVE FLANGE BOLTS.
2. FLANGES ON STEAM LINES OF 600# OR HIGHER PRESSURE SHALL BE COVERED WITH INSULATION AS SPECIFIED ON DRAWING [illegible] EXCEPT AS INDICATED BY SHEET-PIPE-1, THE THICKNESS OF INSULATION OVER VALVE FLANGES FOR THE VARIOUS SYSTEMS AND TEMPERATURES ARE GIVEN BY THE INSULATION AND LAGGING SCHEDULE SHT.-PIPE-2, SEE OF SHEET PIPE-1, SHEET-PIPE-2.
3. ALL FLANGE COVERS TO BE OF CLOTH AND WIRE TYPE OF 1" THICK PLASTIC CEMENT AS SPECIFIED ON DRAWING [illegible] MADE WITH 3/16 ASBESTOS CLOTH, TROWELED AND FINISHED TO A SMOOTH FINISH, AFTER THOROUGHLY WET, BY MEANS OF SODIUM SILICATE AS SPECIFIED ON DRAWING [illegible] THE ASBESTOS CLOTH SHALL THEN BE PAINTED AS REQUIRED BY SPECIFICATION [illegible] OF THE CONTRACT.
4. ALL INSULATION AND LAGGING SHALL MEET THE REQUIREMENTS OF GOVERNMENT SPECIFICATION [illegible]
5. SEPARATE LENGTHS OF LACING WIRE TO BE USED AROUND OUTER TWO COVERS TWISTED AND HOOKED INTO INSULATION. LACING WIRE INDICATED ON PIECE NO. 204 OF PLAN
6. ALL DIMENSIONS ARE IN INCHES.

REFERENCE PLANS

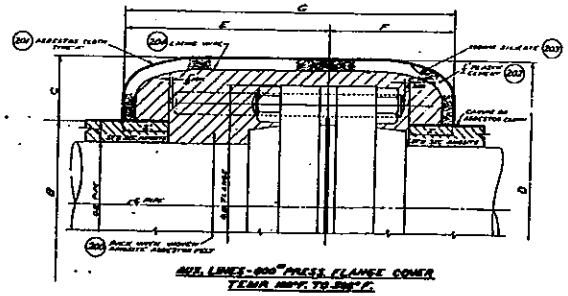
TITLE	[illegible]
[illegible]	[illegible]

AUX. LINES-150# PRESS. BULKHEAD FLANGE COVERS. TEMP. 400°F. TO 700°F.

PIPE SIZE	O.D. PIPE	O.D. FLANGE	A	B	C	D	E	F	NO. OF STUD COVERS	SERVICE
1	.840	3 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		
1 1/4	1.050	4 1/4	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		
1 1/2	1.315	5	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		
2	1.660	6 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		
2 1/2	1.900	7	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		
2	2.375	6	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		
2 1/2	2.875	7	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		
3	3.500	8	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		
3 1/2	4.000	9	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		
4	4.500	10	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		
5	5.563	11	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		
6	6.625	12 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		
8	8.625	15	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		
10	10.750	17 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		
12	12.750	20	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		



AUX. LINES-600# PRESS. BULKHEAD FLANGE COVER
1" THICK, AND BELOW
TEMP. 400°F. TO 700°F.



AUX. LINES-600# PRESS. FLANGE COVER
TEMP. 400°F. TO 700°F.

AUX. LINES-600# PRESS. BULKHEAD FLANGE COVERS. TEMP. 800°F. TO 1000°F.

PIPE SIZE	O.D. PIPE	O.D. FLANGE	A	B	C	D	E	F	NO. OF STUD COVERS	SERVICE
1	.840	4 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		
1 1/4	1.050	5	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		
1 1/2	1.315	5 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2		

AUX. LINES-600# PRESS. FLANGE COVERS. TEMP. 800°F. TO 1000°F.

PIPE SIZE	O.D. PIPE	O.D. FLANGE	A	B	C	D	E	F	G	NO. OF STUD COVERS	SERVICE
1	.840	4 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2	3 1/2		
1 1/4	1.050	5	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2	4		
1 1/2	1.315	5 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2	4 1/2		
2	1.660	6 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2	5		
2 1/2	1.900	7	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2	5 1/2		
2	2.375	6 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2	5		
2 1/2	2.875	7 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2	5 1/2		
3	3.500	8 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2	6		
3 1/2	4.000	9 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2	6 1/2		
4	4.500	10 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2	7		
5	5.563	12	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2	8		
6	6.625	13 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2	9		
8	8.625	16 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2	11		
10	10.750	19	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2	13		
12	12.750	21 1/2	2	2 3/4	3 1/4	3 1/8	4 1/2	5 1/2	15		

NO.	DESCRIPTION	AUTHORITY	BY	DATE
	PLAN APPROVAL, EXTENDING TO DD445-SK-[illegible] INCL.	[illegible]		
	[illegible]	[illegible]		

ALTERATIONS

DD445-SS	BOSTON NAVY YARD
DD445-[illegible]	CHARLESTON NAVY YARD
DD445-[illegible]	PUGET SOUND NAVY YARD
DD445-[illegible]	CHARLESTON NAVY YARD
DD445-[illegible]	BOSTON NAVY YARD

00642-644	[illegible]	
00642-651	[illegible]	
00644-647	[illegible]	
00345-941	BETHLEHEM STEEL CO. SHIPBUILD'G DIV.	
05369-360	CRAMP SHIPBUILDING CO.	
00334-[illegible]	SEATTLE-[illegible] SHIPBUILDING CO.	
00350-363	[illegible] SHIPBUILDING CO.	
00818-382	[illegible]	
00307-317	BETHLEHEM STEEL CO., [illegible] SHIPBUILDING DIV.	
00190-302	[illegible]	
00471	NEW YORK SHIPBUILDING CORP. CAMDEN, N.J.	
00478	[illegible]	
00469	[illegible]	
00468	[illegible]	
00487	[illegible]	
00484	[illegible]	
00463	[illegible]	
00491	[illegible]	
00480	[illegible]	
00498	[illegible]	
00499	[illegible]	
00488	[illegible]	
00446	[illegible]	

DESTROYER NO.	NAME	BUILT BY	NO.
[illegible]	[illegible]	[illegible]	[illegible]

NAVY YARD, BOSTON

APPROVED DD 472-481 - 581-807

DESIGN AND ENGINEERING BY
GIBBS & COX, INC.
NEW YORK

CONT'RS. PLAN NO. 445-3902-6

INSULATION AND LAGGING FOR FLANGE COVERS

BUREAU OF SHIPS PLAN NUMBER
DD445-S3902-6 ALT. 51

NO.	MATL OF ITEMS	QUAN.	SPECIFICATIONS		REMARKS
200	AMOSITE ASBESTOS FELT INSUL.	6803	AMOSITE ASB FELT	32 F 3	1" THICK
201	ASBESTOS CLOTH-40" WIDE	80 YDS	ASBESTOS CLOTH TYPE "A"	32 C 11	
202	PLASTIC CEMENT	3751 LBS	PLASTIC CEMENT	32 C 14	SEE GEN NOTE NO3 BELOW
203	SODIUM SILICATE	6410	ZOSIUM SILICATE	SP. S 29	
204	#16 B.W.G. COPPER WIRE	6803 FT	SOFT COPPER	32 W 9	FOR LACING
205	AMOSITE ASBESTOS FELT INSUL.	6803	AMOSITE ASB FELT	32 F 3	3" THICK

WEIGHT SUMMARY: GROUP XIV SUBJECT 33.01

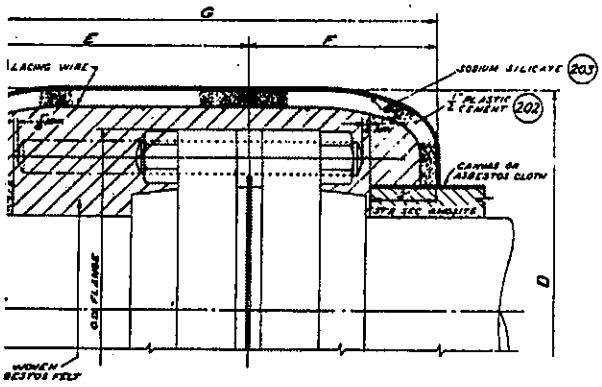
INSULATION	1610
CEMENT	7360
ASBESTOS CLOTH	1070
MISCELLANEOUS	160
TOTAL PER SHIP	16,980 LBS

GENERAL NOTES

1. THIS DRAWING SHOWS FLANGE COVERS FOR PIPE TO PIPE FLANGES ONLY.
2. FLANGES ON STEAM LINES IN WAY OF MACHINERY FREQUENTLY INSPECTED, REPLACED OR REPAIRED, MUST BE COVERED WITH PORTABLE BLANKETS, LACED ON AS INDICATED ON DWG. 445-3903-7, THE THICKNESS OF INSULATION OVER SUCH FLANGES FOR THE VARIOUS SYSTEMS AND TEMPERATURES ARE GIVEN ON THE INSULATION AND LAGGING SCHEDULE 445-3903-5 SH. OF SAME DWG. NO. 00445-53903-9.
3. ALL FLANGE COVERS TO BE ONCALAID WITH ½" THICK PLASTIC CEMENT NO SPECS. 32 C 14 TYPE "A" OR TYPE "B" MIXED WITH 30% PORTLAND CEMENT, TROWELED AND RUBBED TO A SMOOTH FINISH, AFTER THOROUGHLY DRY, APPLY ASBESTOS CLOTH TYPE "A" NO SPECS. 32 C 11 HELD DOWN WITH EITHER INSULATION CEMENT NO SPECS. 32 C 8 OR SODIUM SILICATE NO. SPECS. SP. S 29. THE ASBESTOS CLOTH SHALL THEN BE PAINTED AS REQUIRED BY SUB-PARAGRAPH 319-1.9-3 OF SUBSECTION 3-19-1 OF THE GEN SPECS.
4. ALL INSULATION AND CEMENT MUST MEET THE REQUIREMENTS OF GEN. SPECS. SUBSECTION 339-1 OF JUNE 1, 1940.
5. SEPARATE LOOPS OF LACING WIRE TO BE WOUND AROUND CUFFS, THEN TWISTED TOGETHER AND FORCED INTO INSULATION. LACING WIRE INDICATED AS PIECE NO. 204 ON PLAN
6. ALL DIMENSIONS ARE IN INCHES.

REFERENCE PLANS

TITLE	CONT. PLAN NO.	BUR. OF SHIPS PL. NO.
INSULATION AND LAGGING SCHEDULE ENGINEERING PIPING	445-3903-5	00445-53903-5
TYPICAL INSULATION AND LAGGING DETAILS FOR MISC. STEAM VALVES AND FITTINGS.	445-3903-7	00445-53903-7
SUPERHEAT CONTROL BOILER ARRGT OF VALVES AND FITTINGS	BOSTON PLAN	00445-55405-19

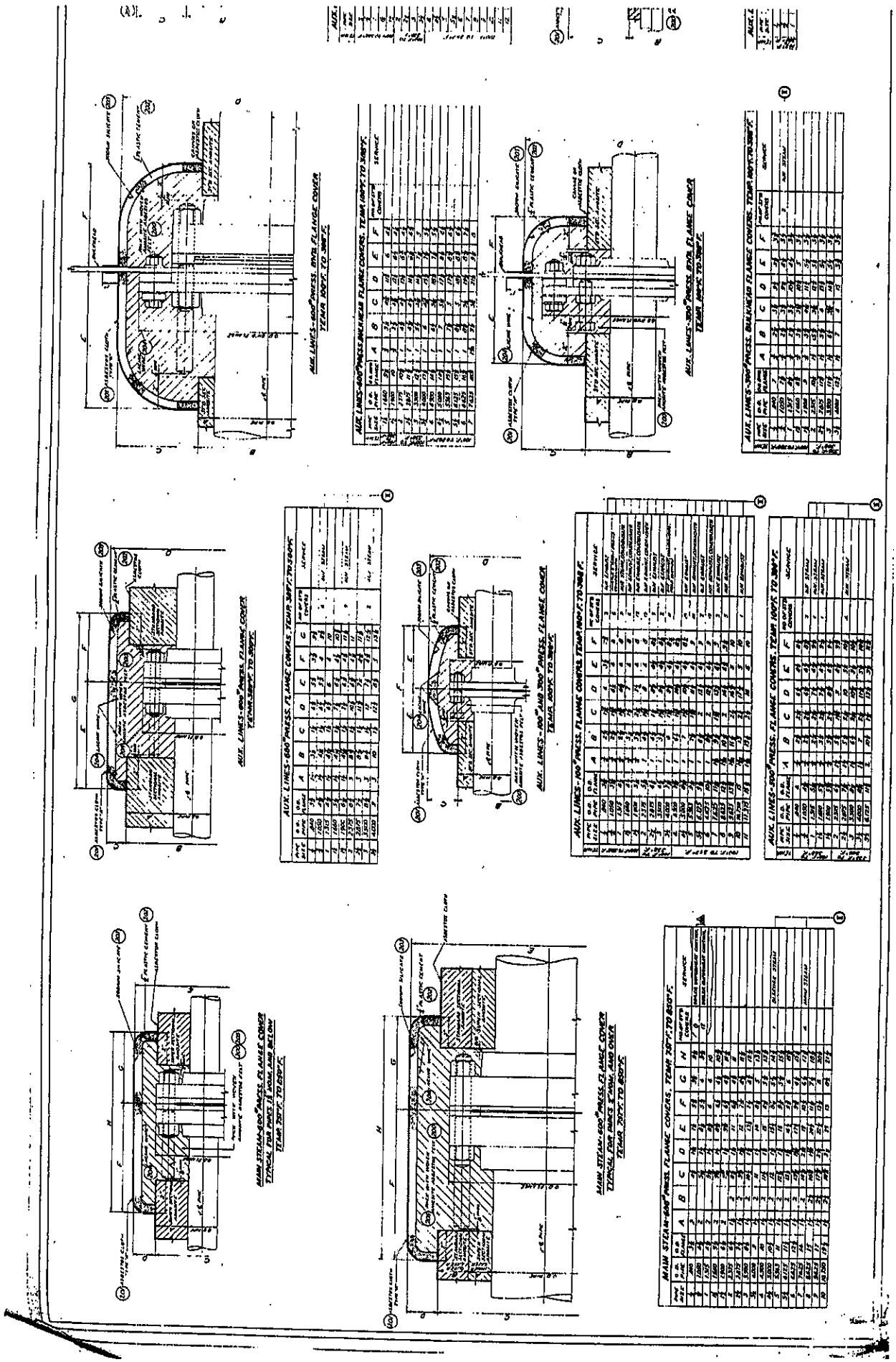


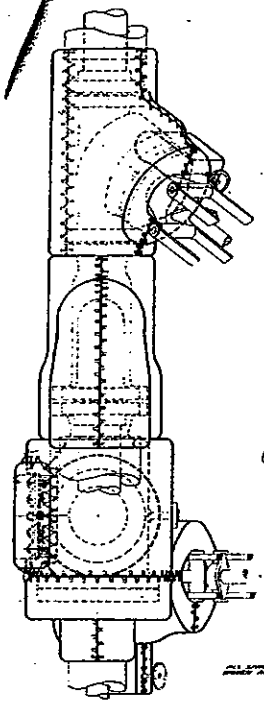
AUX. LINES - 600# PRESS. FLANGE COVER TEMP. 100°F. TO 388°F.

600# PRESS. FLANGE COVERS. TEMP. 100°F. TO 388°F.

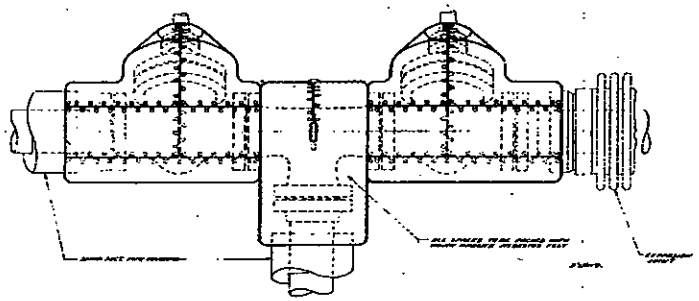
NOS.	A	B	C	D	E	F	G	NO. OF STD COVERS	SERVICE
	¾	2½	1⅜	6½	5½	3½	9½		
	¾	2½	2½	7⅛	5½	4	9½		
	¾	2½	2½	7½	6	4	10		
	¾	3½	2½	7½	6½	4½	10½		
	¾	3½	2½	8½	6½	4½	11½		
	1	4½	2½	9	6½	4½	11		
	1	4½	3½	10	7½	4½	11½		
	1	5½	4½	10½	7½	4½	12½		
	1	6	2½	11½	8½	5	13½		
	1	6½	3	12½	8½	5½	13½	4	FEED DISCHARGE
	1	7	3	13	8½	5½	14½		
	1	7½	2½	13½	9½	5½	15½		
	1	8½	2½	14	9½	6	15½	1	FEED DISCHARGE
	1	8½	3½	15	9½	6½	15½		
	1½	9½	3½	16½	10½	6½	17½		

NO.	DESCRIPTION	AUTHORITY	BY	DATE
	ALTERATIONS			





VIEW "B-B"

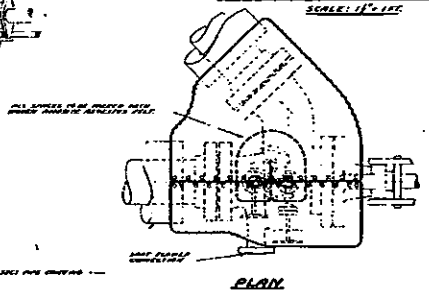


PLAN

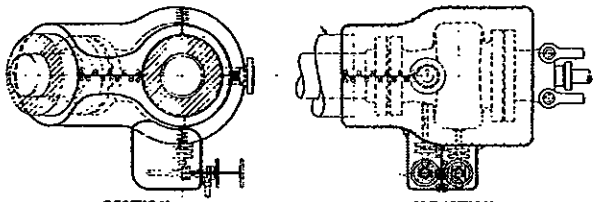
ELEVATION

TYPICAL DETAILS OF BLANKETS FOR MAIN STEAM TEE AND GATE VALVES

SCALE: 1½" = 1FT.



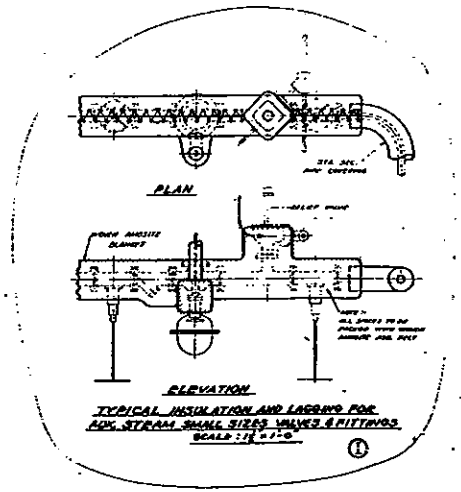
PLAN



SECTION ELEVATION

TYPICAL DETAILS OF BLANKETS FOR BOILER STOP ANGLE VALVES

SCALE: 3" = 1FT.



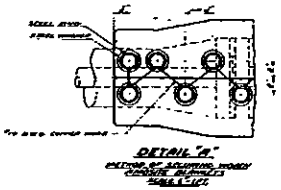
PLAN

ELEVATION

TYPICAL INSULATION AND LAGGING FOR 400 LB. STEAM SMALL SIZES VALVES & FITTINGS

SCALE: 1½" = 1'-0"

1



DETAIL "A"

SECTION OF SOUNDING HOOD CLOSURE BLANKETS

SCALE: 1½" = 1'-0"

IN TYPICAL DETAILS

BLANKETS TO BE MADE IN ACCORDANCE WITH SPECIFICATION

SEAMS AROUND BASE RING TO BE SEWED BY HAND

SEAMS AROUND FLANGE BOLTS TO BE SEWED BY HAND

GENERAL NOTES

1. THIS DRAWING SHOWS TYPICAL INSULATION AND LAGGING CONSTRUCTION TO BE USED ON ALL TYPES OF INSTALLATIONS TO SUIT PIPING ARRANGEMENTS ON SHIP.
2. ALL INSULATION AND LAGGING MUST MEET THE REQUIREMENTS OF GENERAL SPECS SUB-SECTION 330-1 OF JUNE 1ST 1939.
3. FOR INSULATION AND LAGGING INSTALLATION SEE DWG. NO. 445-3902-1 SH. 1 OF SAME SERIES.
4. WHERE WHITE ASBESTOS HONEYCOMB FELT IS CALLED FOR ON THIS DRAWING SAME IS TO BE IN ACCORDANCE WITH N.D. SPECS. 330-1 OF MARCH 1ST 1939.

REFERENCE PLANS

TITLE	SHIP PLAN NO.	SHIP PLAN NO.
INSULATION AND LAGGING SUNDRIES - LOOSE FITTING	445-3902	SHEET NO. 3
INSULATION AND LAGGING DETAILS FOR FLANGED VALVES	445-3902	SHEET NO. 4

NO.	DESCRIPTION	AUTHORITY	BY	DATE
	ALTERATIONS			

DESTROYER NO.	BUILT BY	HULL NO.
00662-64		
00649-665		
00787-797	PUGET SOUND NAVY YARD	
00477-479	CHARLESTON NAVY YARD	
00781-786	BOSTON NAVY YARD	
00442-444		
00429-431		
00344-347		
00525-541		
00369-380		
00534-568		
00550-553		
00378-522		
00507-517		
00338-342		
00471	SEALE	
00470	BAGLEY	
00469	DE WOLF	
00468	TAYLOR	
00467	STRONG	
00466	MILLER	
00465	SAMPLEY	
00451	CHEVALIER	
00450	STODDARD	
00449	NICHOLAS	
00448	LA VALLETTE	
00447	EDWARDS	
00446	RADFORD	
00445	FLETCHER	

NAVY YARD, BOSTON

APPROVED re DD472-481 re 581-597

DESIGN AND ENGINEERING BY GIBBS & COX, INC. NEW YORK

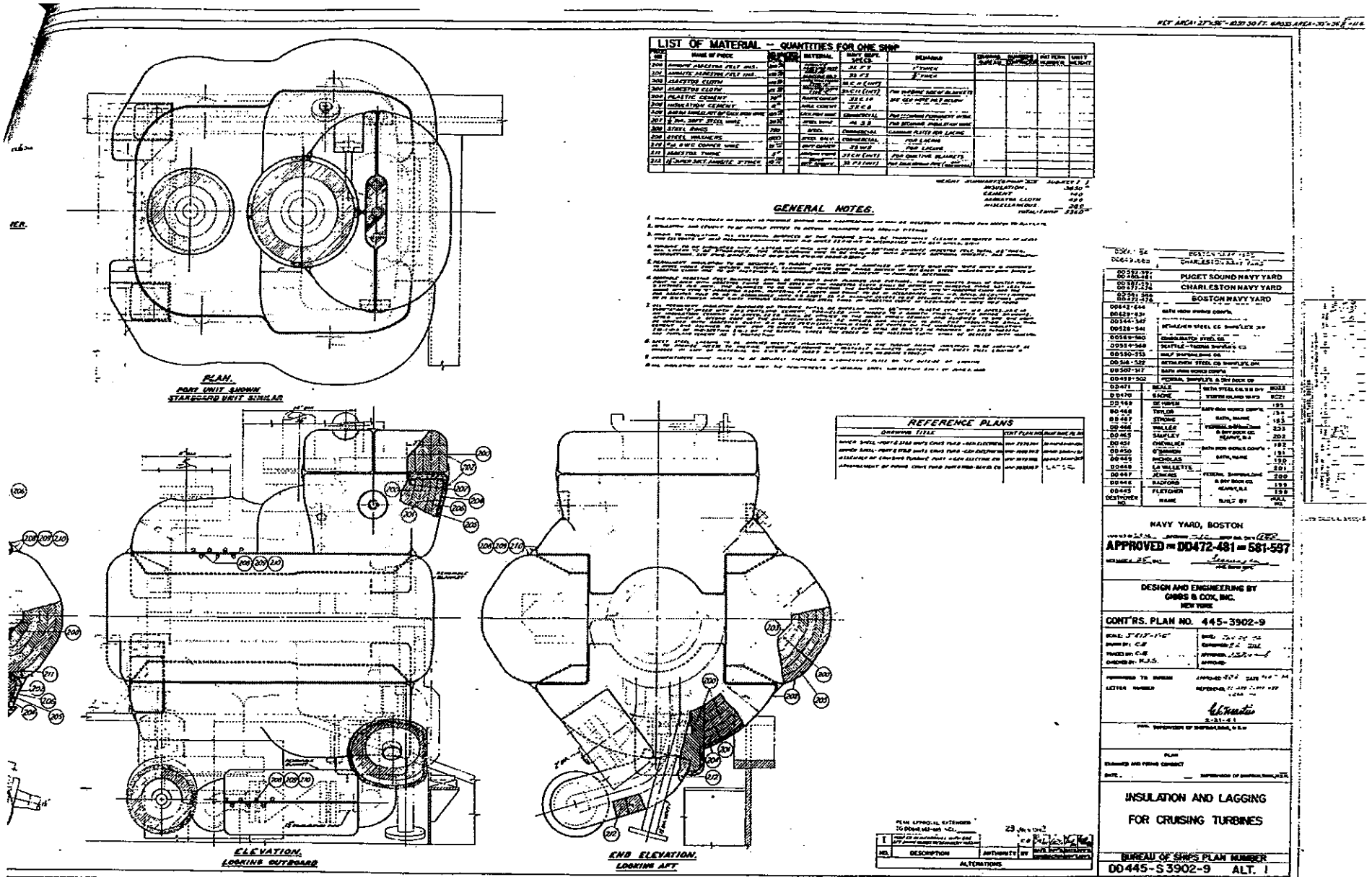
CONTRS. PLAN NO. 445-3902-7

3-7-41

TYPICAL INSULATION AND LAGGING DETAILS FOR MISC. STEAM VALVES AND FITTINGS

BUREAU OF SHIPS PLAN NUMBER

DD445-S3902-7 ALT!



LIST OF MATERIAL – QUANTITIES FOR ONE SHIP

PIECE NO.	NAME OF PIECE	REQUIRED ONE SHIP	UNIT	MATERIAL	NAVY DEPT. SPECS.	REMARKS	DRAWING NUMBERS BUREAU	DRAWING NUMBERS CONTRACTOR	PATTERN NUMBER	UNIT WEIGHT
200	AMOSITE ASBESTOS FELT INS.	280	SF	AMOSITE ASBESTOS FELT	32 F 2	1" THICK				
201	AMOSITE ASBESTOS FELT INS.	180	SF	AMOSITE ASBESTOS FELT	32 F 2	2" THICK				
203	ASBESTOS CLOTH	100	SF	ASBESTOS CLOTH TYPE "A"	32 C 11 (INT)					
202	ASBESTOS CLOTH	45	SF	ASBESTOS CLOTH TYPE "C"	32 C 11 (INT)	FOR TURBINE SIDE OF BLANKETS				
204	PLASTIC CEMENT	70	#	PLASTIC CEMENT	32 C 14	SEE GEN. NOTE NO. 7 BELOW				
205	INSULATION CEMENT	8	#	INSUL. CEMENT	32 C 8					
206	048 BIA. ANNEAL. HOT DIP GALV. IRON WIRE	180	#	GALV. IRON WIRE	COMMERCIAL	FOR SECURING PERMANENT INSUL.				
207	1/4" DIA. SOFT STEEL WIRE	3012	FT	STEEL WIRE	46 S 2	FOR SECURING INSULATION WIRE				
208	STEEL RINGS	720		STEEL	COMMERCIAL	CADMIUM PLATED FOR LACING				
209	STEEL WASHERS	1800		STEEL GALV.	COMMERCIAL	FOR LACING				
210	#14 B.W.G. COPPER WIRE	25	FT	SOFT COPPER	33 W 3	FOR LACING				
211	ASBESTOS TWINE	3	#	ASBESTOS TWINE	32 C 11 (INT)	FOR QUILTING BLANKETS				
212	1" SUPER SECT. AMOSITE 2" THICK	10	FT	SUPER SECT. AMOSITE	32 P 3 (INT)	FOR INSULATION PIPE (See Note 8 Below)				

WEIGHT SUMMARY: (GROUP XXX SUBJECT 1)

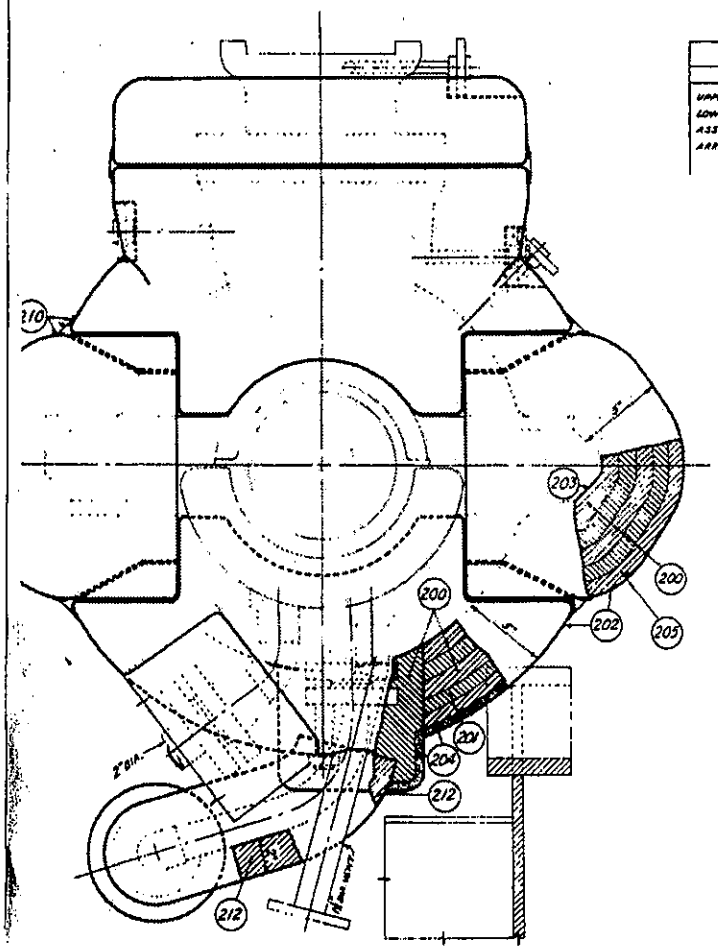
INSULATION	3850 #
CEMENT	140
ASBESTOS CLOTH	490
MISCELLANEOUS	280
TOTAL - 1 SHIP	5360 #

GENERAL NOTES.

1. THIS PLAN TO BE FOLLOWED AS CLOSELY AS POSSIBLE MAKING SUCH MODIFICATIONS AS MAY BE NECESSARY TO PROVIDE FOR ACCESS TO BOLTS, ETC.
2. INSULATION AND CEMENT TO BE NEATLY FITTED TO ACTUAL MACHINERY AND AROUND FITTINGS.
3. PRIOR TO INSULATING, ALL EXTERNAL SURFACES OF THE TURBINE SHALL BE THOROUGHLY CLEANED AND COATED WITH AT LEAST TWO (2) COATS OF HEAT RESISTING ALUMINIUM PAINT NAVY SPECS. 52 P 10 INT. IN ACCORDANCE WITH GEN. SPECS. 5181.
4. TURBINE TO BE INSULATED WITH 3 LAYERS OF 1" THICK AND 3 LAYERS OF 2" THICK AMOSITE ASBESTOS FELT, TOTAL 9" THICK. LAST LAYER TO FURNISH SURFACE FOR EQUILIBRIUM PIPE TO BE INSULATED WITH 2" SUPER SECTIONAL AMOSITE. FOR INSTALLATION INSTRUCTIONS, SEE NAVY DEPT. BUAER - 39681-S BU OF SHIPS NAVY DEPT. NO. BUAER-S 39681-S.
5. PERMANENT INSULATION TO BE SECURED TO TURBINE WITH .048" DIA. ANNEALED HOT DIPPED GALV. IRON WIRE WHICH IS FASTENED TO STEEL HOOKS, SPOT WELDED TO TURBINE. CADMIUM PLATED STEEL RINGS BACKED UP BY GALV. STEEL WASHERS ON BOTH SIDES OF ASBESTOS CLOTH ARE TO BE FASTENED TO PERMANENT INSULATION ADJACENT TO PORTABLE SECTIONS.
6. PORTABLE ASBESTOS FELT BLANKETS SHALL BE PROVIDED OVER BLANKETS AND FITTINGS. THESE BLANKETS SHALL BE QUILTED FROM TWINE, TO SPACE WITH ASBESTOS TWINE AND THE EDGES OF THE ASBESTOS CLOTH SHALL BE SEWED WITH ASBESTOS TWINE NOT LESS THAN 3 STITCHES PER INCH. THE BLANKETS TO BE MADE BY COVERING THE OUTSIDE SURFACE WITH TYPE "A" ASBESTOS CLOTH AND THE INSIDE WITH TYPE "C" ASBESTOS CLOTH. MATERIAL FOR CLOTH AND TWINE TO BE IN ACCORDANCE WITH NAVY DEPT. SPECS. 32 C 11 (INT.) MATERIAL FOR ASBESTOS FELT TO BE IN ACCORDANCE WITH NAVY DEPT. SPECS. 32 F 2. BLANKET COVERS TO BE SECURED TO PERMANENT SECTIONS WITH #8 W.G. COPPER WIRE LACED THROUGH CADMIUM PLATED STEEL RINGS IN ASBESTOS CLOTH AS DESCRIBED IN NOTE NO. 5 ABOVE.
7. ALL PERMANENT INSULATION SURFACES OF TURBINE SHALL BE OVERLAID WITH 1/8" THICK PLASTIC CEMENT NAVY SPECS 32 C 14 TYPE "A" OR "B" MIXED WITH 3 LBS. PORTLAND CEMENT, TROWELED AND RUBBED TO A SMOOTH FINISH. AFTER DRYING 24 HOURS AN INSULATION CEMENT NAVY SPEC. 32 C 8 SHALL BE APPLIED TO THE HARD FINISH CEMENT AND ALLOWED TO DRY ONE HOUR AFTER WHICH A SECOND COAT OF THE SAME CEMENT SHALL BE APPLIED AND ALLOWED TO DRY. THE INSULATION SHALL THEN BE COVERED WITH ASBESTOS CLOTH NAVY SPECS. 32 C 11 (INT.) WHICH SHALL BE GLUED ON THE UNDERSIDE WITH INSULATION CEMENT AND ALLOWED TO DRY FOR 12 HOURS. THE ASBESTOS CLOTH SHALL BE PAINTED AS REQUIRED BY SUB-PARAGRAPH 12-41-3 (c) (2) (b) SUB-SECTION 3181 OF THE GENERAL SPECS. THE JOINTS OF THE ASBESTOS CLOTH SHALL BE BEVELED WITH ASBESTOS AND PORTLAND CEMENT AS A PROTECTION.
8. ASBESTOS STEEL LAGGING TO BE APPLIED OVER THE INSULATION ADJACENT TO THE TURBINE PACKING INSULATION TO BE ARRANGED SO AS TO PROVIDE ACCESS TO PACKING WITHOUT REMOVING THE PORTABLE BLANKETS. MATERIAL FOR SPLIT STEEL LAGGING IS ORDERED IN LIST OF MATERIAL ON BU & E SHIPS DWG NO. 68442-S 39683-S AND 68442-S 39684-S.
9. MANUFACTURERS NAME PLATE TO BE SECURELY FASTENED IN A CONVENIENT PLACE ON THE OUTSIDE OF LAGGING.
10. ALL INSULATION AND CEMENT MUST MEET THE REQUIREMENTS OF GENERAL SPECS SUBSECTION 3181 OF JUNE 1, 1940.

REFERENCE PLANS

DRAWING TITLE	CONT. PLAN NO.	BUSHIPS PL. NO.
UPPER SHELL - PORT & STBD UNITS CRUIS. TURB. - GEN ELECTRIC CO.	WW 3939301	20443-34101-120
LOWER SHELL - PORT & STBD. UNITS CRUIS TURB - GEN ELECTRIC CO.	WW-3939302	20443-34101-121
ASSEMBLY OF CRUISING TURBINE PORT - GEN ELECTRIC CO.	WW-3939308	20443-34101-205
ARRANGEMENT OF PIPING CRUIS. TURB PORT & STBD - GEN EL CO.	WW-3939387	

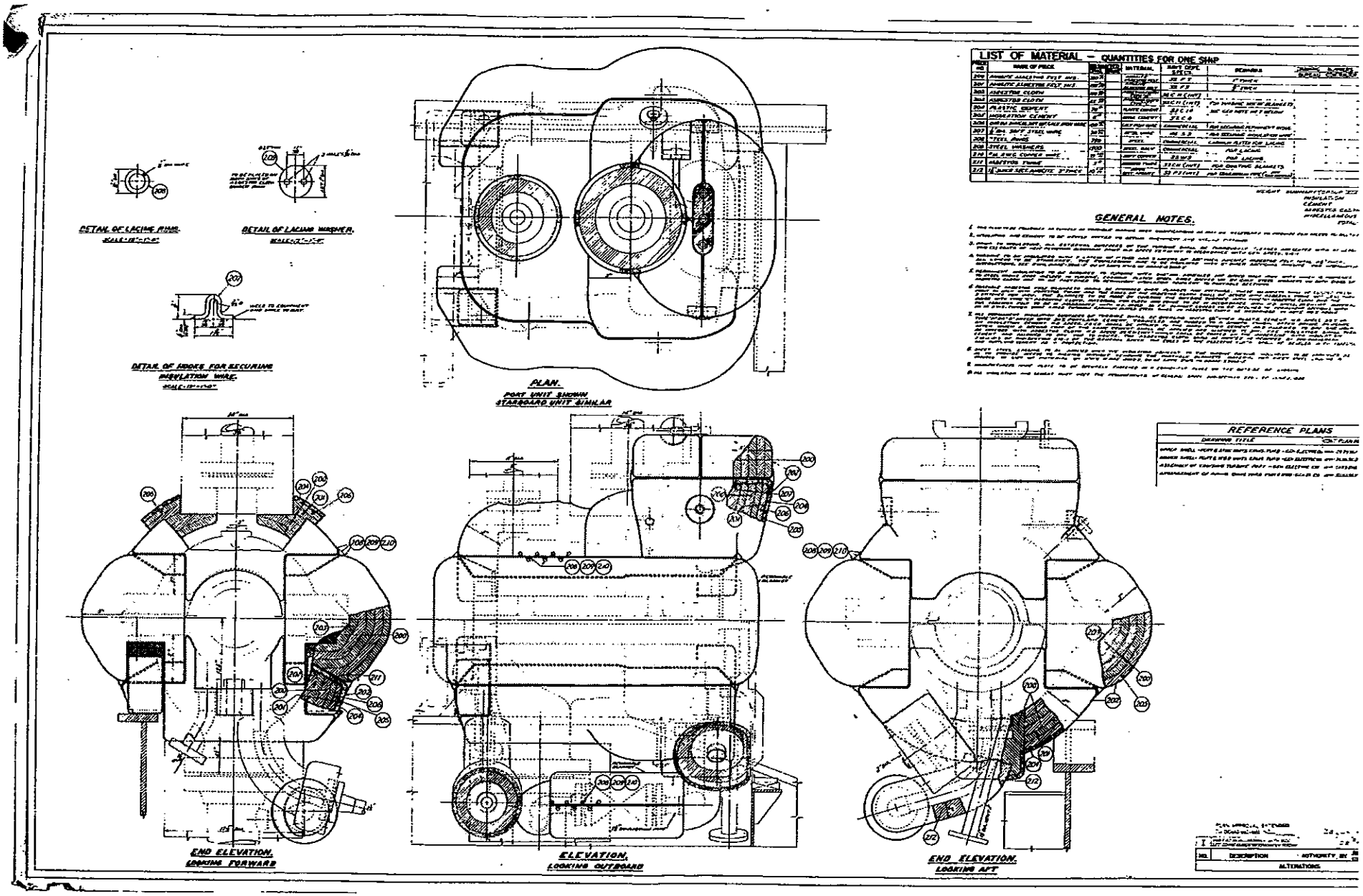


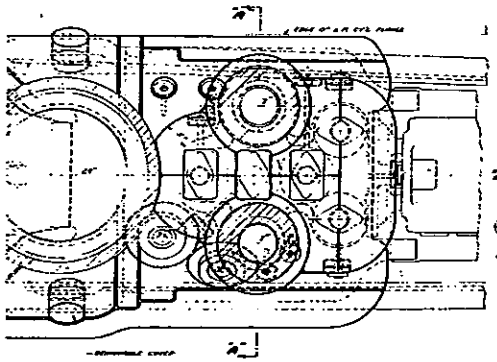
END ELEVATION.
LOOKING AFT

PLAN APPROVAL EXTENDED TO DD MM, 00/-005 NCL.

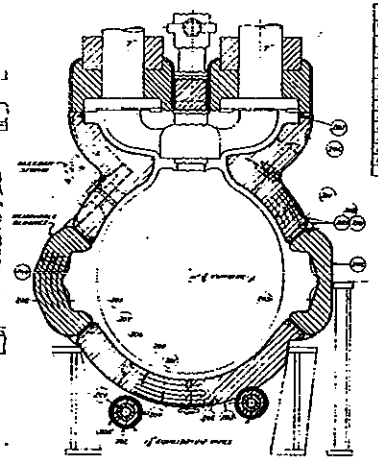
NO.	DESCRIPTION	AUTHORITY	BY	DATE APP'D BUSHIPS	DATE APP'D CONTRACTOR
1	MADE CB IN ALLOWANCE WITH SEC. 1ST BOAT CLASS 38'2" DIA. PROP.		CB	8-14-40	10-11-40

ALTERATIONS

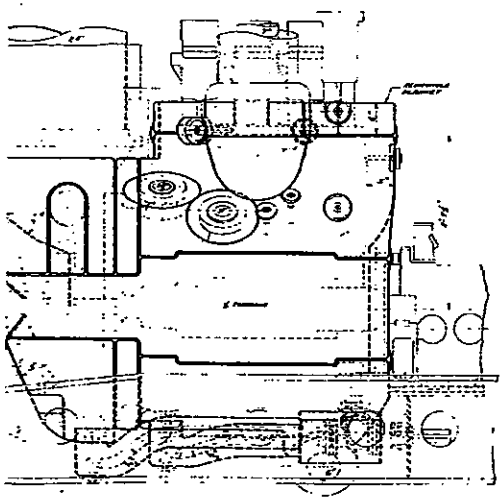




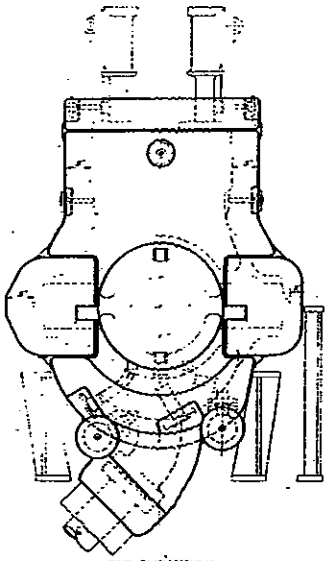
PLAN
STARBOARD TURBINE SHOWN
PORT TURBINE SIMILAR



SECTION "A-A"



ELEVATION
LOOKING INBOARD



END ELEVATION
LOOKING AFT

LIST OF MATERIAL—QUANTITIES FOR ONE SHIP

ITEM NO.	NAME OF PIECE	No. REQ'D	MAT'L	MAT'L SPECIFICATIONS	REMARKS	DRAWING NUMBER	PATTERN NO.	UNIT WEIGHT
100	ASBESTOS MANGANESE FELT (SHEET)	1 THK			1" THICK			
101	ASBESTOS ASBESTOS FELT (ROLL)	1 WIDE			1" THICK			
102	CANVAS CLOTH	1 WIDE						
103	ASBESTOS CLOTH	1 WIDE						
104	PLASTIC CEMENT							
105	INSULATION CEMENT							
106								
107								
200	STEEL PLATES							
201	STEEL ANGLES							
202	STEEL CHANNELS							
203	STEEL ANGLES							
204	STEEL BARS							
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297	STEEL PLATES							
298	STEEL ANGLES							
299	STEEL CHANNELS							
300	STEEL BARS							

WEIGHT SUMMARY (EXCLUSIVE OF ASBESTOS)
INSULATION (TOTAL) ____ 19400 LBS
CEMENT ____ 1800 "
FINISHED COATS ____ 800 "
MISCELLANEOUS ____ 200 "
TOTAL SHIP ____ 22200 "

GENERAL NOTES

1. THIS PLAN TO BE FOLLOWED AS CLOSELY AS POSSIBLE BEFORE SHIP ARRANGEMENT IS MADE BUT ALLOWANCE TO BE MADE FOR CHANGES THAT ACCRUE TO SHIP'S USE.
2. INSULATION AND CEMENT TO BE CAREFULLY FITTED TO ACTUAL MEASUREMENTS AFTER ALL PIPING IS TESTED.
3. PRIOR TO INSULATION, ALL EXTERIOR SURFACES OF PIPE THROUGH SHELL OR THROUGHOUT CLEANED AND COATED WITH AT LEAST TWO (2) COATS OF HOT BITUMINOUS ALUMINUM PAINT AS PER SPECIFICATIONS NO. 46 SPECIFICATIONS NO. 46 SPECIFICATIONS NO. 46
4. THROUGH THE ARMORED DECK 3 LAYERS OF 1" THICK AND TWO LAYERS OF 2" THICK MAGNESIA ASBESTOS FELT, TRIAL OF WHICH ARE SATISFACTORY HAVE TO BE MEASURED WITH THE LAYERS OF THICK MAGNESIA ASBESTOS FELT. NONE OF THESE ALL LAYERS ARE TO BE SHOWN.
5. PERMANENT INSULATION TO BE SECURED TO DECKING WITH BRASS OR GALVANIZED HOT DIPPED GALVANIZED IRON STRAPS AS PER DETAILS TO SUIT VARIOUS SHIP DETAILS TO THICKNESS, CONFORMING PLATES, STEEL FRAMES AROUND OR OF ALL STEEL STRUCTURES AND WORK SHALL BE MADE TIGHT CLOTH AND TO BE SECURED TO PERMANENT INSULATING MATERIAL TO PORTABLE SECTIONS.
6. PORTABLE ASBESTOS FELT BLANKETS, SHALL BE PROVIDED OVER FLANGES AND FITTINGS. THESE BLANKETS SHALL BE MADE FREE FROM JOINT TO BACK WITH ADJOINING ITEMS, AND THE EDGES OF THE BLANKETS CLOTH SHALL BE SEWED WITH ASBESTOS THREAD AND LESS THAN 2 STITCHES PER INCH. THE BLANKETS TO BE MADE AT CONTRACTOR'S SHOP AND FITTED IN POSITION AFTER THE PIPING AND MACHINERY WITH TYPE "E" ASBESTOS CLOTH, AND SHALL NOT CLOTH WHICH SHALL BE IN ACCORDANCE WITH SPECIFICATIONS. THE FINISHED CLOTH SHALL BE IN ACCORDANCE WITH A.S.A. SPECIFICATIONS NO. 46 SPECIFICATIONS NO. 46 SPECIFICATIONS NO. 46
7. ALL PERMANENT INSULATION SURFACES OF THROUGH SHELL TO BE COVERED WITH 6" THICK PLASTIC CEMENT AND SHALL BE FINISHED WITH 2" THICK MAGNESIA ASBESTOS FELT, TRIAL OF WHICH ARE SATISFACTORY HAVE TO BE MEASURED WITH THE LAYERS OF THICK MAGNESIA ASBESTOS FELT. NONE OF THESE ALL LAYERS ARE TO BE SHOWN.
8. SHEET STEEL LAGGING TO BE APPLIED ONLY FOR INSULATION EXPOSED TO THE THROAT PROCESS, LAGGING TO BE ARRANGED SO AS NOT TO INTERFERE WITH OPENING FOR INSPECTION AND PARTICULAR ATTENTION TO BE GIVEN TO THE ARRANGEMENT OF LAGGING AT THE BOTTOM OF THE SHIP.
9. CONTRACTOR'S NAME PLATE TO BE SECURELY RIVETED IN A CONVENIENT PLACE ON THE BOTTOM OF LAGGING.
10. ALL INSULATION AND CEMENT MUST MEET THE REQUIREMENTS OF U.S.N. SPECS. 3410 SECTION 3.3.3.4 OF JUNE 1, 1940.

REFERENCE PLANS

TITLE	CONT'R'S PLAN NO.	BU. SPECIFICATIONS
21" FORWARD SHELL - APPROX. APPLY	445-3902-10	46
21" AFTERWARD SHELL - APPROX. APPLY	445-3902-10	46
21" FORWARD EXHAUST CASING - APPROX. APPLY	445-3902-10	46
21" AFTERWARD EXHAUST CASING - APPROX. APPLY	445-3902-10	46

CODE & EX DD64946dev	BOSTON NAVY YARD / CHARLESTON NAVY YARD
DD 472-327 / DD 462-461	PUGET SOUND NAVY YARD
DD 467-371 / DD 472-479	CHARLESTON NAVY YARD
DD 461-498 / DD 472-481	BOSTON NAVY YARD

DD 642-644			
DD 639-631			
DD 544-549			
DD 328-341			
DD 543-580			
DD 558-548			
DD 533-553			
DD 518-522			
DD 507-517			
DD 498-502			
DD 471	SCALE		8022
DD 470	SHORE		8021
DD 469	DE HAVEN		195
DD 468	TAYLOR		194
DD 467	STRONG		193
DD 466	WALKER		203
DD 465	SHIFLEY		202
DD 464	CHEVALIER		192
DD 450	STANNARD		191
DD 445	NICHOLAS		190
DD 446	LA VALLETTE		200
DD 447	JENKINS		200
DD 448	RADFORD		200
DD 443	FLETCHER		190
DESTROYER	NAME	BUILT BY	HULL

NAVY YARD, BOSTON
APPROVED for DD 472-481 & 581-587
DESIGN AND ENGINEERING BY GIBBS & COX, INC. NEW YORK
CONT'RS. PLAN NO. 445-3902-10
3-21-41

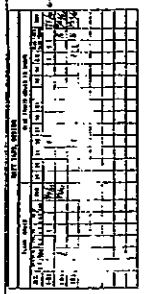
INSULATION AND LAGGING
FOR H.P. TURBINES

BUREAU OF SHIPS PLAN NUMBER
DD 445-53902-10 MT 1

PLAN APPROVED, EXTENDED TO DRAWING ____ INCL. 29 JAN 15

NO.	DESCRIPTION	AUTHORITY	BY	DATE
1				
2				
3				

ALTERATIONS



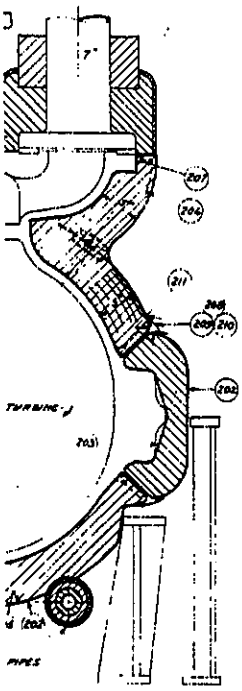
NET AREA - 27" x 14" x 10.20# GROSS AREA 30" x 36"

LIST OF MATERIAL—QUANTITIES FOR ONE SHIP

PIECE NO.	NAME OF PIECE	NO. REQUIRED ONE SHIP	MATERIAL	NAVY DEPT. SPECIFICATIONS	REMARKS	DRAWING NUMBER BUREAU	DRAWING NUMBER CONTRACTOR	PATTERN NO.	UNIT WEIGHT
200	ANDALUSITE ASBESTOS FELT INSUL.	615#	ANDALUSITE ASBESTOS FELT	32 F 3	1" THICK				
201	ANDALUSITE ASBESTOS FELT INSUL.	440#	ANDALUSITE ASBESTOS FELT	32 F 3	½" THICK				
202	ASBESTOS CLOTH	340#	ASBESTOS CLOTH TYPE "A"	32 C 11(INT)					
203	ASBESTOS CLOTH	80#	ASBESTOS CLOTH TYPE "B"	32 C 11(INT)	FOR TURBINE SIDE OF BLANKETS				
204	PLASTIC CEMENT	180#	PLASTIC CEMENT	32 C 16 (INT)	SEE G&M NOTE NO 7 BELOW				
205	INSULATION CEMENT	10#	INSUL CEMENT	32 C 8					
206	#9 B.W.G. ANNEAL. NOT GALVANIZED WIRE	250'	GALVANIZED IRON WIRE	COMMERCIAL	FOR SECURING PERMANENT INSUL				
207	¼" DIA. SOFT STEEL WIRE	30'	STEEL WIRE	46 S 2	FOR SECURING INSULATION WIRE				
208	STEEL RINGS	450	STEEL	COMMERCIAL	CADMIUM PLATED FOR LACING				
209	STEEL WASHERS	1300	STEEL GALV.	COMMERCIAL	FOR LACING				
210	#8 B.W.G. COPPER WIRE	130'	SOFT COPPER	32 W 9	FOR LACING				
211	ASBESTOS TWINE	7#	BRAIDING TWINE	32 C 11 (INT)	FOR QUILTING BLANKETS				

WEIGHT SUMMARY: (GROUP XVI SUBGP 1)

INSULATION (FELT)	950.0 LBS
CEMENT	180.0
ASBESTOS CLOTH	80.0
MISCELLANEOUS	30.0
TOTAL (1 SHIP)	1260.0 LBS



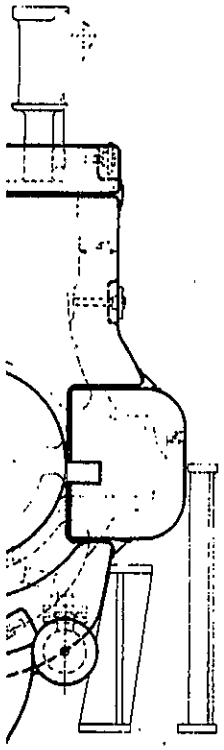
"A-A"

GENERAL NOTES

1. THIS PLAN TO BE FOLLOWED AS CLOSELY AS POSSIBLE MAKING SUCH MODIFICATIONS AS MAY BE NECESSARY TO PROVIDE FOR ACCESS TO BOLTS ETC
2. INSULATION AND CEMENT TO BE NEATLY FITTED TO ACTUAL MACHINERY AND AROUND FITTINGS
3. PRIOR TO INSULATING, ALL EXTERNAL SURFACES OF THE TURBINE SHALL BE THOROUGHLY CLEANED AND COATED WITH AT LEAST TWO (2) COATS OF HEAT RESISTING ALUMINUM PAINT N.D SPECS 52 P(INT) IN ACCORDANCE GEN SPECS 519-1
4. TURBINE TO BE INSULATED WITH 3 LAYERS OF 1" THICK AND TWO LAYERS OF ½" THICK ANDOSITE ASBESTOS FELT TOTAL 4½" THICK THE EQUILIBRIUM PIPE TO BE INSULATED WITH TWO LAYERS ½" THICK ANDOSITE ASBESTOS FELT. TOTAL 1" THICK IN 4 LAYERS TO BE STAGGERED
5. PERMANENT INSULATION TO BE SECURED TO TURBINE WITH #9 B.W.G. DIA ANNEALED HOT DIPPED GALV IRON WIRE WHICH IS FASTENED TO STEEL HOOKS SPOT WELDED TO TURBINE, CADMIUM PLATED STEEL RINGS BACKED UP BY GALV STEEL WASHERS ON BOTH SIDES OF ASBESTOS CLOTH ARE TO BE FASTENED TO PERMANENT INSULATION ADJACENT TO PORTABLE SECTIONS.
6. PORTABLE ASBESTOS FELT BLANKETS SHALL BE PROVIDED OVER FLANGES AND FITTINGS. THESE BLANKETS SHALL BE QUILTED FROM FRONT TO BACK WITH ASBESTOS TWINE, AND THE EDGES OF THE ASBESTOS CLOTH SHALL BE SEWED WITH ASBESTOS TWINE NOT LESS THAN 3 STITCHES PER INCH. THE BLANKETS TO BE MADE BY COVERING THE OUTSIDE SURFACE WITH TYPE "A" ASBESTOS CLOTH AND THE INSIDE WITH TYPE "B" ASBESTOS CLOTH. MATERIAL FOR CLOTH AND TWINE TO BE IN ACCORDANCE WITH N.D. SPECS, 32 C 11(INT). MATERIAL FOR ASBESTOS FELT TO BE IN ACCORDANCE WITH N.D SPECS 32 F 3. BLANKET COVERS TO BE SECURED TO PERMANENT SECTIONS WITH #9 M B.W.G. COPPER WIRE LACED THROUGH CADMIUM PLATED STEEL RINGS IN ASBESTOS CLOTH AS DESCRIBED IN NOTE NO 5 ABOVE.
7. ALL PERMANENT INSULATION SURFACES OF TURBINE SHALL BE OVERLAID WITH ½" THICK PLASTIC CEMENT N.D SPECS. 32 C 16(INT) TYPE "A" OR "B" MIXED WITH 20% PORTLAND CEMENT TROWELLED AND RUBBED TO A SMOOTH FINISH. AFTER DRYING 24 HOURS, AN INSUL CEMENT N.D. SPECS. 32 C 8 SHALL BE APPLIED TO THE HARD FINISH CEMENT AND ALLOWED TO DRY ONE HOUR AFTER WHICH A SECOND COAT OF THE SAME CEMENT SHALL BE APPLIED AND ALLOWED TO DRY. THE INSULATION SHALL THEN BE COVERED WITH ASBESTOS CLOTH N.D. SPECS. 32 C 11(INT) WHICH SHALL BE COATED ON THE UNDERSIDE WITH INSULATION CEMENT AND ALLOWED TO DRY FOR 72 HOURS. THE ASBESTOS CLOTH SHALL BE PAINTED AS REQUIRED BY SUB-PARAGRAPH 519-1 g-2 OF SUB-SECTION 519-1 OF THE G&M SPECS. THE EDGES OF THE ASBESTOS CLOTH SHALL BE BEVELED WITH ASBESTOS AND PORTLAND CEMENT AS A PROTECTION
8. SHEET STEEL LAGGING TO BE APPLIED OVER THE INSULATION ADJACENT TO THE TURBINE PACKING, INSULATION TO BE ARRANGED SO AS TO PROVIDE ACCESS TO PACKING WITHOUT REMOVING THE PORTABLE BLANKETS. MATERIAL FOR SHEET STEEL LAGGING IS ORDERED IN LIST OF MATERIAL ON DWG. 993-3902-S BU NO 08488-33908-3
9. MANUFACTURER'S NAME PLATE TO BE SECURELY FASTENED IN A CONVENIENT PLACE ON THE OUTSIDE OF LAGGING.
10. ~~INSULATION AND LAGGING FOR GEN ELECTRIC N.D TURBINES AS SHOWN HEREIN APPLIES TO N.D TURBINES ONLY USE INSULATION AND LAGGING TO BE FURNISHED~~ (S1)
11. ALL INSULATION AND CEMENT MUST MEET THE REQUIREMENTS OF G&M SPECS SUB-SECTION 539-1 OF JUNE 1, 1940.

REFERENCE PLANS

TITLE		CONT PLAN NO	BU SHIP'S PLANS
H.P TURBINE SHELL UPPER HALF	G.E. ELECT MFG CO.	WW 5939 308	99445-3401-26
H.P. TURBINE SHELL LOWER HALF	GEN. ELECT. MFG. CO.	WW 5939 309	99445-3401-27
H.P TURBINE EXHAUST CASING - UPPER HALF	GEN ELECT MFG CO	WW 5939 319	99445-3401-73
H.P TURBINE EXHAUST CASING - LOWER HALF	GEN. ELECT MFG CO	WW 5939 306	99445-3401-28



PLAN APPROVAL EXTENDED TO DD&M, [illegible] INCL. 29 JAN 15

NO.	DESCRIPTION	AUTHORITY	BY	DATE	APP'D	DATE	APP'D
				CONTRACTOR		GOV'T. APP'L	
1	MODIFIED IN ACCORDANCE WITH S.B.S. LETTER 89-A-AE CLASS (2-21) 2339 (2437-ME) OF FEBRUARY 17, 1941		A.B.K.	2/11/41	[illegible]	2/11/41	[illegible]

ALTERATIONS